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Standards of Performance for the control of emissions from the beverage can surface coating industry are being proposed under the authority of section 111 of the Clean Air Act. These standards would apply to all beverage can surface coating lines for which construction or modification began on or after the date of proposal of the regulations. This document contains background information and environmental and economic assessments of the regulatory alternatives considered in developing the proposed standards.

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Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

September 1980

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ENVIRONMENTAL PROTECTION AGENCY

Background Information
and Draft
Environmental Impact Statement
for
Beverage Can Surface Coating Industry

Prepared by:

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1. The proposed standards of performance would limit emissions of volatile organic compounds from new, modified, and reconstructed beverage can surface coating lines. Section 111 of the Clean Air Act (42 USC 7411), as amended, directs the Administrator to establish standards of performance for any category of new stationary sources of air pollution which "causes or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare." All regions are affected.

2. Copies of this document have been sent to the Department of Labor; Department of Agriculture; Department of Commerce; Council of Environmental Quality; members of the State and Territorial Air Pollution Program Administrators (STAPPA), and the Association of Local Air Pollution Control Officials (ALAPCO); to EPA Regional Administrators; and to other interested parties.

3. The comment period for review of this document is 60 days and is expected to begin on or about September 25, 1980.

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1. SUMMARY

1.1 REGULATORY ALTERNATIVES

Section 111 of the Clean Air Act (42 U.S.C. 7411) as amended directs the Administrator to establish standards of performance for any category of new stationary sources of air pollution that "causes or contributes significantly to air pollution which may reasonably be anticipated to endanger public health and welfare." The beverage can surface coating industry has been determined to fall into this classification and standards of performance have been developed for volatile organic compounds (VOC).

Three regulatory alternatives are considered. The first involves no additional regulation. Emissions from new, modified, or reconstructed beverage plants would be governed by State regulations.

The second regulatory alternative would limit emissions to those that would result from the use of best available waterborne coatings. These emission limitations may also be met through the use of solvent-borne coatings and emission control systems.

The third regulatory alternative is the same as the second except that no-varnish inks or radiation-curable coatings are used in applying the lithography and or overvarnish coats.

1.2 ENVIRONMENTAL IMPACT

Under Regulatory Alternative I, there would be no environmental impact, either beneficial or adverse. VOC emissions under Regulatory Alternative II would be reduced by 7,500 Mg per year in 1985 and under Regulatory Alternative III by 8,900 Mg. No adverse economic impacts would result from any of the regulatory alternatives. A matrix summarizing the environmental and economic imports is presented in Table 1-1.

TABLE 1-1. ASSESSMENT OF ENVIRONMENTAL AND ECONOMIC IMPACTS FOR EACH REGULATORY ALTERNATIVE CONSIDERED

Administrative action	Air impact	Water impact	Solid waste impact	Energy impact	Noise impact	Economic impact
Regulatory Alternative I	1	0	0	0	0	0
Regulatory Alternative II	1*	0	0	+1*	0	0
Regulatory Alternative III	1*	0	0	+2*	0	0
Delayed standard	1	0	0	0	0	0
No standard	1	0	0	0	0	0

KEY:
+ Beneficial impact
0 No impact
1 Negligible
2 Small impact
* Long-term impact

1.3 ECONOMIC IMPACT

No adverse economic impacts on the beverage can industry are likely to occur under any of the regulatory alternatives. Control options that are equal to or less than the cost of complying with the emission limitations specified by SIPs are available for each production facility. Some control options, if used, would impact the affected facilities.

Under Regulatory Alternative II, the use of solvent-borne coatings and an emission control system would result in price increases of less than 2 percent for two-piece beverage can production facilities. An additional capital outlay of up to 5 percent would be required, depending on the size of the facility. Regulatory Alternative III would have no impact on two-piece lines even if solvent-borne coatings were used.

2. INTRODUCTION

2.1 BACKGROUND AND AUTHORITY FOR STANDARDS

Before standards of performance are proposed as a Federal regulation, air pollution control methods available to the affected industry and the associated costs of installing and maintaining the control equipment are examined in detail. Various levels of control based on different technologies and degrees of efficiency are expressed as regulatory alternatives. Each of these alternatives is studied by EPA as a prospective basis for a standard. The alternatives are investigated in terms of their impacts on the economics and well-being of the industry, the impacts on the national economy, and the impacts on the environment. This document summarizes the information obtained through these studies so that interested persons will be able to see the information considered by EPA in the development of the proposed standard.

Standards of performance for new stationary sources are established under Section 111 of the Clean Air Act (42 U.S.C. 7411) as amended, hereinafter referred to as the Act. Section 111 directs the Administrator to establish standards of performance for any category of new stationary source of air pollution which ". . . causes, or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare."

The Act requires that standards of performance for stationary sources reflect ". . . the degree of emission reduction achievable which (taking into consideration the cost of achieving such emission reduction, and any nonair quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated for that category of sources." The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

The 1977 amendments to the Act altered or added numerous provisions that apply to the process of establishing standards of performance.

1. EPA is required to list the categories of major stationary sources that have not already been listed and regulated under standards of performance. Regulations must be promulgated for these new categories on the following schedule:

   a. 25 percent of the listed categories by August 7, 1980.

   b. 75 percent of the listed categories by August 7, 1981.

   c. 100 percent of the listed categories by August 7, 1982.

A governor of a State may apply to the Administrator to add a category not on the list or may apply to the Administrator to have a standard of performance revised.

2. EPA is required to review the standards of performance every 4 years and, if appropriate, revise them.

3. EPA is authorized to promulgate a standard based on design, equipment, work practice, or operational procedures when a standard based on emission levels is not feasible.

4. The term "standards of performance" is redefined, and a new term "technological system of continuous emission reduction" is defined. The new definitions clarify that the control system must be continuous and may include a low- or non-polluting process or operation.

5. The time between the proposal and promulgation of a standard under section 111 of the Act may be extended to 6 months.

Standards of performance, by themselves, do not guarantee protection of health or welfare because they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect the degree of emission limitation achievable through application of the best adequately demonstrated technological system of continuous emission reduction, taking into consideration the cost of achieving such emission reduction, any non-air-quality health and environmental impacts, and energy requirements.

Congress had several reasons for including these requirements. First, standards with a degree of uniformity are needed to avoid situations where some States may attract industries by relaxing standards relative to other States. Second, stringent standards enhance the potential for long-term growth. Third, stringent standards may help achieve long-term cost savings by avoiding the need for more expensive retrofitting when pollution ceilings may be reduced in the future. Fourth, certain types of standards for coal-burning sources can adversely affect the coal market by driving up the price of low-sulfur coal or effectively excluding certain coals from the reserve base because their untreated pollution potentials are high. Congress does not intend that new source performance standards contribute to these problems. Fifth, the standard-setting process should create incentives for improved technology.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. States are free under section 116 of the Act to establish even more stringent emission limits than those established under Section 111 or those necessary to attain or maintain the National Ambient Air Quality Standards (NAAQS) under Section 110. Thus, new sources may in some cases be subject to limitations more stringent than standards of performance under Section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

A similar situation may arise when a major emitting facility is to be constructed in a geographic area that falls under the prevention of significant deterioration of air quality provisions of Part C of the Act. These provisions require, among other things, that major emitting facilities to be constructed in such areas are to be subject to best available control technology. The term Best Available Control Technology (BACT), as defined in the Act, means

> . . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from, or which results from, any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of each such pollutant. In no event shall application of "best available control technology" result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to sections 111 or 112 of this Act. (Section 169(3))

Although standards of performance are normally structured in terms of numerical emission limits where feasible, alternative approaches are sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive. Section 111(h) provides that the Administrator may promulgate a design or equipment standard in those cases where it is not feasible to prescribe or enforce a standard of performance. For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions, high concentrations for short periods during filling and low concentrations for longer periods during storage, and the configuration of storage tanks make direct emission measurement impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

In addition, Section 111(j) authorizes the Administrator to grant waivers of compliance to permit a source to use innovative continuous emission control technology. In order to grant the waiver, the Administrator must find: (1) a substantial likelihood that the technology will produce greater emission reductions than the standards require or an equivalent reduction at lower economic energy or environmental cost; (2) the proposed system has not been adequately demonstrated; (3) the technology will not cause or contribute to an unreasonable risk to the public health, welfare, or safety; (4) the governor of the State where the source is located consents; and (5) the waiver will not prevent the attainment or maintenance of any ambient standard. A waiver may have conditions attached to assure the source will not prevent attainment of any NAAQS. Any such condition will have the force of a performance standard. Finally, waivers have definite end dates and may be terminated earlier if the conditions are not met or if the system fails to perform as expected. In such a case, the source may be given up to 3 years to meet the standards with a mandatory progress schedule.

2.2 SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 of the Act directs the Adminstrator to list categories of stationary sources. The Administrator ". . . shall include a category of sources in such list if in his judgment it causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare." Proposal and promulgation of standards of performance are to follow.

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a system for assigning priorities to various source categories. The approach specifies areas of interest by considering the broad strategy of the Agency for implementing the Clean Air Act. Often, these "areas" are actually pollutants emitted by stationary sources. Source categories that emit these pollutants are evaluated and ranked by a process involving such factors as (1) the level of emission control (if any) already required by State regulations, (2) estimated levels of control that might be required from standards of performance for the source category, (3) projections of growth and replacement of existing facilities for the source category, and (4) the estimated incremental amount of air pollution that could be prevented in a preselected future year by standards of performance for the source category. Sources for which new source performance standards were promulgated or under development during 1977, or earlier, were selected on these criteria.

The Act amendments of August 1977 establish specific criteria to be used in determining priorities for all major source categories not yet listed by EPA. These are (1) the quantity of air pollutant emissions that each such category will emit, or will be designed to emit; (2) the extent to which each such pollutant may reasonably be anticipated to endanger public health or welfare; and (3) the mobility and competitive nature of each such category of sources and the consequent need for nationally applicable new source standards of performance.

The Administrator is to promulgate standards for these categories according to the schedule referred to earlier.

In some cases it may not be feasible immediately to develop a standard for a source category with a high priority. This might happen when a program of research is needed to develop control techniques or because techniques for sampling and measuring emissions may require refinement. In the developing of standards, differences in the time required to complete the necessary investigation for different source categories must also be considered. For example, substantially more time may be necessary if numerous pollutants must be investigated from a single source category. Further, even late in the development process the schedule for completion of a standard may change. For example, inablility to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling. Nevertheless, priority ranking is, and will continue to be, used to establish the order in which projects are initiated and resources assigned.

After the source category has been chosen, the types of facilities within the source category to which the standard will apply must be determined. A source category may have several facilities that cause air pollution, and emissions from some of these facilities may vary from insignificant to very expensive to control. Economic studies of the source category and of applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there is no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by a standard of performance, not all pollutants or facilities within that source category may be covered by the standards.

2.3 PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Standards of performance must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost, the non-air-quality health and environmental impacts, and the energy requirements of such control; (3) be applicable to existing sources that are modified or reconstructed as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

The objective of a program for developing standards is to identify the best technological system of continuous emission reduction that has been adequately demonstrated. The standard-setting process involves three principal phases of activity: (1) information gathering, (2) analysis of the information, and (3) development of the standard of performance.

During the information-gathering phase, industries are queried through a telephone survey, letters of inquiry, and plant visits by EPA representatives. Information is also gathered from many other sources, and a literature search is conducted. From the knowledge acquired about the industry, EPA selects certain plants at which emission tests are conducted to provide reliable data that characterize the pollutant emissions from well-controlled existing facilities.

In the second phase of a project, the information about the industry and the pollutants emitted is used in analytical studies. Hypothetical "model plants" are defined to provide a common basis for analysis. The model plant definitions, national pollutant emission data, and existing State regulations governing emissions from the source category are then used in establishing "regulatory alternatives." These regulatory alternatives are essentially different levels of emission control.

EPA conducts studies to determine the impact of each regulatory alternative on the economics of the industry and on the national economy, on the environment, and on energy consumption. From several possibly applicable alternatives, EPA selects the single most plausible regulatory alternative as the basis for a standard of performance for the source category under study.

In the third phase of a project, the selected regulatory alternative is translated into a standard of performance, which, in turn, is written in the form of a Federal regulation. The Federal regulation, when applied to newly constructed plants, will limit emissions to the levels indicated in the selected regulatory alternative.

As early as is practical in each standard-setting project, EPA representatives discuss the possibilities of a standard and the form it might take with members of the National Air Pollution Control Techniques Advisory Committee. Industry representatives and other interested parties also participate in these meetings.

The information acquired in the project is summarized in the Background Information Document (BID). The BID, the standard, and a preamble explaining the standard are widely circulated to the industry being considered for control, environmental groups, other government agencies, and offices within EPA. Through this extensive review process, the points of view of expert reviewers are taken into consideration as changes are made to the documentation.

A "proposal package" is assembled and sent through the offices of EPA Assistant Administrators for concurrence before the proposed standard is officially endorsed by the EPA Administrator. After being approved by the EPA Administrator, the preamble and the proposed regulation are published in the Federal Register.

As a part of the Federal Register announcement of the proposed regulation, the public is invited to participate in the standard-setting process. EPA invites written comments on the proposal and also holds a public hearing to discuss the proposed standard with interested parties. All public comments are summarized and incorporated into a second volume of the BID. All information reviewed and generated in studies in support of the standard of performance is available to the public in a "docket" on file in Washington, D.C.

Comments from the public are evaluated, and the standard of performance may be altered in response to the comments.

The significant comments and EPA's position on the issues raised are included in the "preamble" of a "promulgation package," which also contains the draft of the final regulation. The regulation is then subjected to another round of review and refinement until it is approved by the EPA Administrator. After the Administrator signs the regulation, it is published as a "final rule" in the Federal Register.

2.4 CONSIDERATION OF COSTS

Section 317 of the Act requires an economic impact assessment with respect to any standard of performance established under Section 111 of the Act. The assessment is required to contain an analysis of (1) the costs of compliance with the regulation, including the extent to which the cost of compliance varies depending on the effective date of the regulation and the development of less expensive or more efficient methods of compliance; (2) the potential inflationary or recessionary effects of the regulation; (3) the effects the regulation might have on small business with respect to competition; (4) the effects of the regulation on consumer costs; and (5) the effects of the regulation on energy use. Section 317 also requires that the economic impact assessment be as extensive as practicable.

The economic impact of a proposed standard upon an industry is usually addressed both in absolute terms and in terms of the control costs that would be incurred as a result of compliance with typical, existing State control regulations. An incremental approach is necessary because both new and existing plants would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the economic impact from the cost differential that would exist between a proposed standard of performance and the typical State standard.

Air pollutant emissions may cause water pollution problems, and captured potential air pollutants may pose a solid waste disposal problem. The total environmental impact of an emission source must, therefore, be analyzed and the costs determined whenever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made for proposed standards. It is also essential to know the capital requirements for pollution control systems already placed on plants so that the additional capital requirements necessitated by these Federal standards can be placed in proper perspective. Finally, it is necessary to assess the availability of capital to provide the additional control equipment needed to meet the standards of performance.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decisionmaking process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards of performance for various industries, the United States Court of Appeals for the District of Columbia Circuit has held that environmental impact statements need not be prepared by the Agency for proposed actions under Section 111 of the Clean Air Act. Essentially, the Court of Appeals has determined that the best system of emission reduction requires the Administrator to take into account counterproductive environmental effects of a proposed standard, as well as economic costs to the industry. On this basis, therefore, the Court established a narrow exemption from NEPA for EPA determination under Section 111.

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to Section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969." (15 U.S.C. 793(c)(1))

Nevertheless, the Agency has concluded that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, although not legally required to do so by Section 102(2)(C) of NEPA, EPA has adopted a policy requiring that environmental impact statements be prepared for various regulatory actions, including standards of performance developed under Section 111 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, a separate section in this document is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are discussed.

2.6 IMPACT ON EXISTING SOURCES

Section 111 of the Act defines a new source as ". . . any stationary source, the construction or modification of which is commenced . . ." after the proposed standards are published. An existing source is redefined as a new source if "modified" or "reconstructed" as defined in amendments to the general provisions of Subpart A of 40 CFR Part 60, which were promulgated in the Federal Register on December 16, 1975 (40 FR 58416).

Promulgation of a standard of performance requires States to establish standards of performance for existing sources in the same industry under Section 111 (d) of the Act if the standard for new sources limits emissions of a designated pollutant (i.e., a pollutant for which air quality criteria have not been issued under Section 108 or which has not been listed as a hazardous pollutant under Section 112). If a State does not act, EPA must establish such standards. General provisions outlining procedures for control of existing sources under Section 111(d) were promulgated on November 17, 1975, as Subpart B of 40 CFR Part 60 (40 FR 53340).

2.7 REVISION OF STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, Section 111 of the Act provides that the Administrator ". . . shall, at least every 4 years, review and, if appropriate, revise . . ." the standards. Revisions are made to assure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive, but will apply to stationary sources constructed or modified after the proposal of the revised standards.

3. THE BEVERAGE CAN COATING INDUSTRY

3.1 GENERAL

The metal can industry is defined in the Standard Industrial Classification Manual under SIC 3411 as establishments primarily engaged in manufacturing metal cans from purchased materials. Beverage cans are included in this category. As used in this report the term "beverage cans" includes two-piece and three-piece metal containers for soft drinks and beer (including malt liquors).

According to the Can Manufacturers Institute, in 1976 approximately 100 companies with almost 500 plants at 300 locations in the United States manufactured metal cans of all types.[1]

In 1978 there were 48,500 production workers in the can industry. This represented a 19 percent decrease from 1973, when 60,200 production workers were employed in the industry. Approximately half of these workers were in the beverage can sector. Total industry employment in 1978 was 58,500, compared to 69,800 workers in 1973. This gradual reduction in employment can be attributed to the closing of marginal facilities and the installation of more efficient equipment, especially in beverage can manufacture, where relatively labor-intensive facilities for three-piece can lines have been giving way to more productive two-piece can lines. Approximately half of the industry work force is estimated to be in the beverage can sector.

Beverage cans are made in two-piece and three-piece styles. Two-piece beverage can bodies are made of steel or aluminum. The top for two-piece beverage cans is made of aluminum regardless of the body material. The three-piece beverage can is similar to that used in the food industry and, except for the top, is made of steel. The top is made of aluminum to permit easy pull-tab opening.

A protective coating is applied to the inside of both two- and three-piece beverage cans to isolate the contents from the metal can body. A protective coating may or may not be applied to the exterior surface prior to lithography. In some cases an overvarnish is applied to protect the lithography, to improve appearance, and to increase mobility during filling operations.

In 1978 over 54 billion beverage cans were produced. Use, type, and construction materials of these cans are shown in Table 3-1.[2]

3.2 PROCESSES OR FACILITIES AND THEIR EMISSIONS

A two-piece beverage can is made by forming the body and bottom end in one piece by the draw and wall-iron method (DWI). The DWI method uses coiled stock, which is cupped in a press and the walls of the cup drawn or extended to the desired container height. Such cans have considerably thicker bottoms than side walls. An aluminum top is attached after the can is filled.

A three-piece beverage can is made of two end pieces and a rectangular sheet (body blank), to which base coats, lithography, and overvarnish have been applied. The precoated metal sheet is slit to body size and rolled or formed into a tubular body and soldered, welded or cement sealed at the seam. An inside spray is applied and one end is attached to the body by roll seaming. The other end is attached during packaging of the product.

The materials used in fabricating two-piece beverage cans are aluminum and malleable steel. Materials used in fabricating three-piece cans are tinplate and tin-free steel (TFS). These materials range in thickness from 0.006 to 0.15 inch. Sheet sizes vary, depending on the can style. Twelve-ounce beverage cans are usually made from steel sheets of 30-by-32 inches to 37-by-42 inches. A typical sheet yields 35 12-ounce can bodies.

3.2.1 Two-Piece Beverage Can Coating

Two-piece beverage cans bodies are coated after fabrication. The coatings used depend on end use or customer specifications. Two-piece beverage cans consist of a steel or aluminum body and an aluminum end (top). Four separate coats may be applied to the can body: exterior base coat, lithography/overvarnish coat, inside spray coat, and bottom coat.

TABLE 3-1. NUMBER OF BEVERAGE CANS BY CONSTRUCTION PROCESS, 1978

	Number (billions)	Percent of total
Beer	28.9	53.2
Three piece	2.5	4.7
Two piece	26.4	48.5
Steel	5.8	10.7
Aluminum	20.6	37.8
Soft drinks	25.5	46.8
Three piece	12.0	22.0
Two piece	13.5	24.9
Steel	4.0	7.4
Aluminum	9.5	17.5
Total	54.4	100
Three piece	14.5	26.6
Two piece	39.9	73.4
Steel	9.8	18.1
Aluminum	30.1	55.3

The aluminum ends are formed from precoated aluminum coils or sheets with only the end-sealing compound being applied at the beverage can plant.

The process for coating two-piece cans begins after the can has been formed, except for necking and flanging operations. The coating process is in line with the fabrication process. Prior to coating, the cans are washed to remove oil and dirt. Aluminum cans are usually pretreated with an agent to improve paint bonding and corrosion resistance. The cans proceed to the coating area at rates in the range of 600 to 800 cans per minute per line. In 1978 one vender began marketing modular two-piece beverage can lines with a 500 can-per-minute capacity. One such line is scheduled to begin operation in the United States for a major canmaker. While no other modular lines are on order, the vendor reports that negotiations are under way for one other domestic line.[3] [4]

After cleaning and treatment, an exterior base coat may be applied using a mandrel coating system. The coated cans usually proceed on a pin conveyor to an oven that bakes the coating. Upon leaving the oven, the cans are conveyed to printing and overvarnish machines. Mandrel coatings are used to apply up to four colors followed by application of an overvarnish if desired. Recently, inks requiring no overvarnish (no-var inks) have been accepted by some companies. Cans are then oven or radiation cured.

The cans proceed in the process lines to the inside spray application station. Inside body spray is applied by spray nozzles as each can travels around a turret. The coated cans are then oven cured, leak tested, necked and flanged, and palletized for shipment.

Can bottoms are roll or spray coated as part of one of the three coating operations, i.e., base coat, lithography/overvarnish, or inside spray. The entire bottom of steel two-piece cans is coated; only the rim of aluminum cans is coated.

The aluminum end of a two-piece can is stamped from precoated aluminum coil or sheet, after which an end-sealing compound is applied. The end is attached to the can after filling. The only emissions attributable to the two-piece can line are from the application of end-sealing compound.

Except for end-sealing operation, emissions occur at the coater, flashoff area (the area between the coater and cure oven), and cure oven for each of the coating operations described above. For end-sealing compound, emissions occur at the applicator and the area in which they are air dried. Distribution of total plant emissions for a plant using waterborne coatings is estimated to be:[5]

	Percent of total emissions	
Operation	Ends made at plant	Ends not made at plant
Exterior base coat	10	12
Lithography	4	5
Overvarnish	15	18
Bottom coat	1	1
Inside spray	55	64
End sealing	15	-

A process flow sheet (Figure 3-1) illustrates the steps in the manufacture of a two-piece beverage can.

3.2.2 Three-Piece Beverage Can Coating

Can stock, ready for use, is received as coils or palletized bundles of sheets. If stock is in coil form, it is cut into sheets before coating. Three separate coats are applied using roll coaters: an interior base coat, an exterior base coat, and a lithography/overvarnish coat.

The interior base coat is usually applied first. This coat provides protection for both the contents of the can and the can itself. The coated sheet is then conveyed to a wicket-type oven where the coat is cured. The wickets travelling on the oven conveyor hold the sheets in an upright position as they are conveyed through the oven. The oven has a cooling zone in which the sheets cool to near room temperature. As they emerge from the oven the sheets are stacked and transported to the next operation. The exterior base coat is applied to the opposite side of the sheet, using a similar procedure.

After the exterior and interior base coats are applied, the sheet is ready for lithography and overvarnish. These coatings are applied in one continuous operation. Litho-offset with either dry or wet plates is normally used. The printed sheets are then usually roll-coated with an overvarnish coating over the wet, uncured ink. Use of specially formulated inks may obviate the requirement for application of overvarnish. After application, the lithography/overvarnish coat is heat cured by passing the sheets through a wicket oven, or radiation cured.

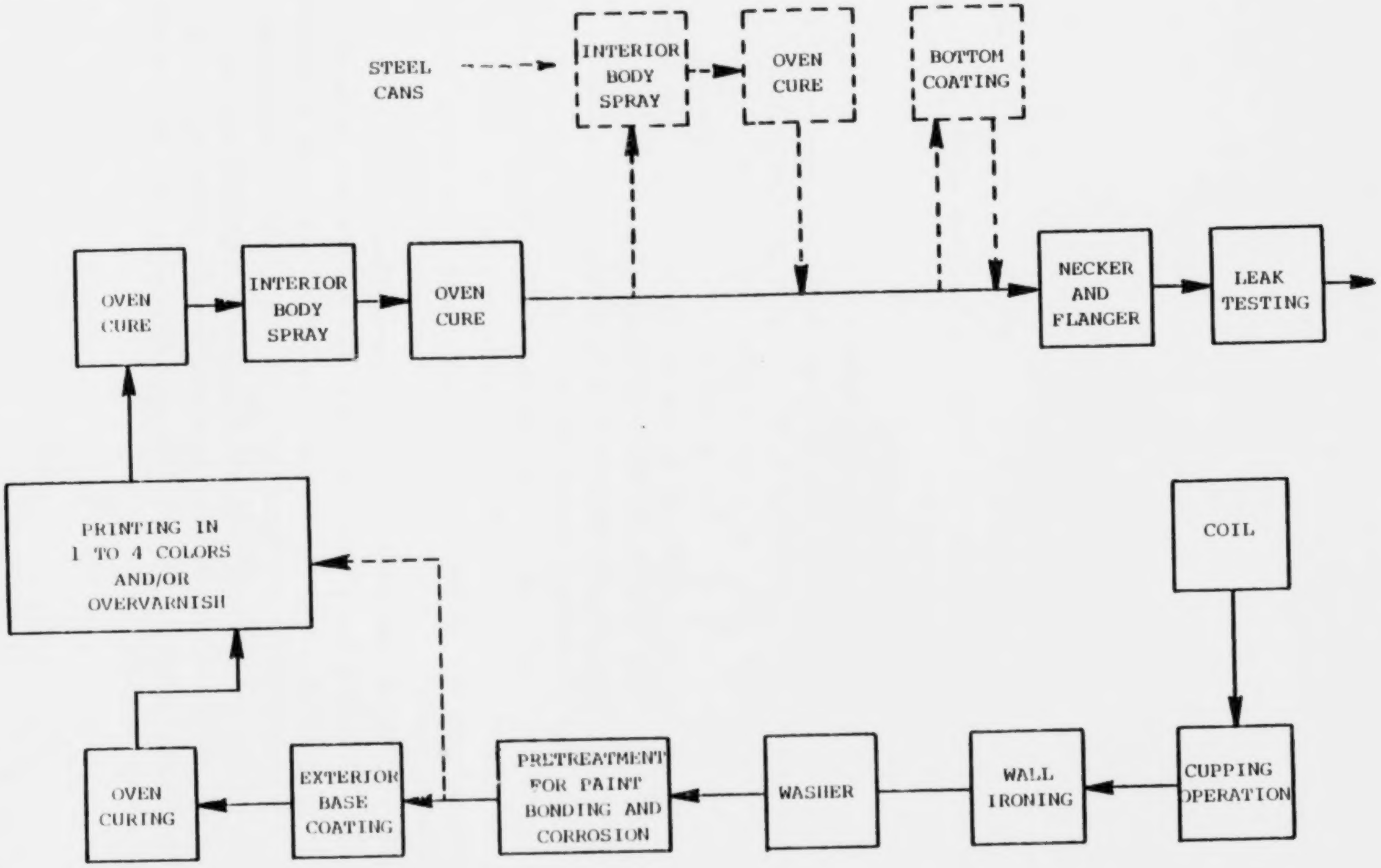
STEEL CANS
INTERIOR BODY SPRAY
OVEN CURE
BOTTOM COATING
OVEN CURE
INTERIOR BODY SPRAY
OVEN CURE
NECKER AND FLANGER
LEAK TESTING
PRINTING IN 1 TO 4 COLORS AND/OR OVERVARNISH
COIL
OVEN CURING
EXTERIOR BASE COATING
PRETREATMENT FOR PAINT BONDING AND CORROSION
WASHER
WALL IRONING
CUPPING OPERATION

Figure 3-1. Process diagram—two-piece can fabricating and coating operation.

Emissions from base coating operations occur at the coater, the flashoff area, and the cure oven. Emissions from the flashoff area and cure oven emanate from the coating applied to the can; emissions from the coater include VOC from the coating and from the solvent that is used to continuously clean the coater rolls when solvent-borne base coatings are used.

The bodymaking process forms beverage cans from the coated sheets. Sheets are slit into body-size blanks and fed into a bodymaker, which forms the body blank into a cylinder. The seam is welded, cemented, or soldered, and usually sprayed on the inside and outside of the seam with an air-dry lacquer to protect the exposed metal. Emissions from seam coating are relatively minor, representing from 2 to 4 percent of total emissions.[6 7] The cylinders are flanged to provide proper can end assembly.

The interior of the cylinder is sprayed with a coating to ensure a protective lining between the beverage and the can. Emission points from three-piece beverage can inside-spraying operations are the coater, flashoff area, and cure oven.

Three-piece cans usually have one end attached at this point. The cans are tested for leakage, then stacked and palletized for shipment. Bottoms of three-piece cans are made of steel; tops or tabbed ends are made of aluminum. Can ends are stamped from precoated sheets or coils in a reciprocating press and the perimeter coated with a rubber end-sealing compound that functions as a gasket when the end is attached to the can. End-sealing compounds for beverage cans in use today are almost exclusively solvent-based compounds that are air dried after application.

Steel ends are formed from sheets to which interior and exterior coats have been applied. After forming, an end-sealing compound is applied. Aluminum ends for three-piece cans are fabricated in the same manner as those for two-piece cans.

Emissions from one three-piece beverage can plant using solvent-borne coatings are reported as being distributed among coating operations as follows.[6]

Operation	Percent of total emissions	
	Ends made at plant	Ends not made at plant
Exterior base coat	24	30
Interior base coat	24	30
Overvarnish	15	19
Inside spray	15	19
Side-seam spray	2	2
End-sealing compound	20	-

Emissions from cleaning operations are included in these figures.

Another plant using solvent-borne coatings reports the following distribution of emissions among operations.[7]

Operation	Percent of total emissions	
	Ends made at plant	Ends not made at plant
Exterior and interior base coat	17	19
Overvarnish	4	5
Inside spray	32	36
Cleanup solvents	35	40
End sealing	12	-

No data were available for plants using waterborne coatings.

A process flow sheet (Figure 3-2) illustrates the steps in the manufacture of a three-piece beverage can. The major coatings for a three-piece beverage can considered in this study are the interior coat, the exterior base coat, the overvarnish, the inside spray, and end-sealing application. Emissions from the process are dependent on the solvent and solids content of the coating used and the thickness of each coating applied.

3.3 BASELINE EMISSIONS

The can manufacturing industry today uses both waterborne and solvent-borne coatings. Cure oven and other exhaust from solvent-borne coatings may or may not be captured and incinerated, depending on the emission limitations imposed by the applicable State Implementation Plan (SIP).

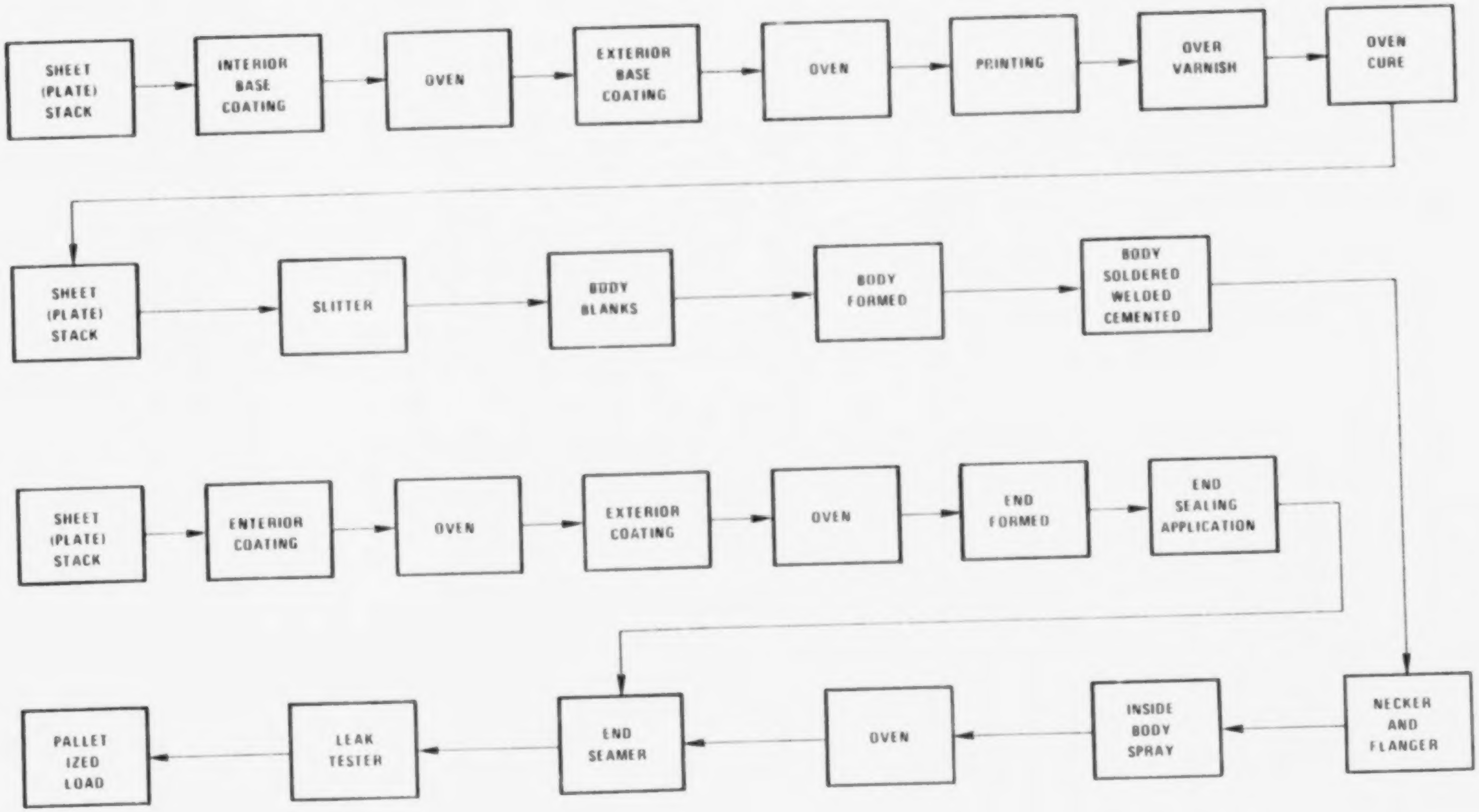
SHEET (PLATE) STACK
INTERIOR BASE COATING
OVEN
EXTERIOR BASE COATING
OVEN
PRINTING
OVER VARNISH
OVEN CURE
SHEET (PLATE) STACK
SLITTER
BODY BLANKS
BODY FORMED
BODY SOLDERED WELDED CEMENTED
SHEET (PLATE) STACK
ENTERIOR COATING
OVEN
EXTERIOR COATING
OVEN
END FORMED
END SEALING APPLICATION
NECKER AND FLANGER
INSIDE BODY SPRAY
OVEN
END SEAMER
LEAK TESTER
PALLET IZED LOAD

Figure 3-2. Process diagram–three-piece steel can fabricating and coating operation.

Upon completion of the current round of SIP revisions, can plants located in oxidant nonattainment areas will be required to meet the regulations based on emission limitations recommended in the control technique guidelines (CTG).[8] To meet these limitations, can plants using solvent-borne coatings would be required to capture and incinerate at least a portion if not all of the VOC emissions, or convert to waterborne coatings.

Emission limitations for beverage can surface coating recommended in the CTG , which will be the baseline emissions for subsequent analyses, are shown in Table 3-2.

Five general base cases, covering eleven coating operations, are used to describe beverage can surface coating. These base cases and the coating operations involved in each are presented below:

- Two-piece steel and aluminum beverage cans
    - Exterior base coat
    - Lithography/overvarnish
    - Inside spray
- Coating of steel stock for three-piece beverage cans
    - Exterior base coat
    - Interior base coat
    - Lithography/overvarnish
- Forming of three-piece beverage cans
    - Inside spray coat
- Steel ends for three-piece beverage cans
    - Exterior coat
    - Interior coat
    - End-sealing application
- Aluminum ends for three-piece and two-piece beverage cans
    - Exterior coat*
    - Interior coat*
    - End-sealing application.

Inside coatings are applied to prevent damage to the can and its contents by corrosion. Exterior coatings are applied to protect the exterior

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*Applicable only when ends are made from aluminum sheets.

TABLE 3-2. CTG-RECOMMENDED EMISSION LIMITATIONS FOR CAN SURFACE COATINGS[8]

Affected facility	Recommended limitation kg per litre of coating (minus water)	 lb per gal of coating (minus water)
Sheet base coat (exterior and interior) and overvarnish; two-piece can exterior (base coat and overvarnish)	0.34	2.8
Two- and three-piece can interior body spray, two-piece can exterior end (spray or roll coat)	0.51	4.2
Three-piece can side-seam spray	0.66	5.5
End-sealing compound	0.44	3.7

of the can from corrosion, and to serve as a base for lithography. Overvarnish is applied following lithography to protect the design from abrasion and to reduce friction for automated can-handling equipment. Traditionally, coating materials have been resins (alkyd, epoxy, acrylic, or polyester) that contain various additives and sometimes pigments or colorants, dissolved or dispersed in vehicles consisting of organic solvents.

In the manufacture of two-piece cans, the coatings are applied to individual can bodies after they have been formed by the drawing and ironing process from uncoated stock. Coatings are oven dried and baked. Exterior coatings are applied to two-piece can bodies by mandrel coating, and interior coatings are applied by spray coating. In the manufacture of bodies for three-piece cans, coatings are applied to flat sheets of can body material by roller coating. The coatings are oven dried and baked. Sheets are then slit into blanks from which the can bodies are formed and inside spray applied.

Steel ends are stamped from precoated coil or roll-coated sheet, and end-sealing compound is applied. Only sheet coating of end steel stock will be discussed in this report, as coil coating is covered by another standard. Depending on customers' requirements, one or more coatings may be omitted in any particular instance. In general, when more than one coating is applied to a can body or sheet, each coating is oven dried and baked before the next coating is applied. Application of two interior spray coats to steel two-piece cans at a recently constructed plant is accomplished without an intermediate curing step.[9]

Aluminum ends are required for all beverage cans. These ends are manufactured from precoated sheets or coils. When aluminum sheet is the raw material, ends are usually made in a three-piece can sheet-coating plant. Exterior and interior coats are applied, the ends stamped from the coated sheet, and end-sealing compound applied. Base coaters used for coating steel sheets are also used for coating the aluminum end sheet stock. When sheet stock is the raw material, aluminum ends are usually made at a merchant facility, for shipment directly to brewery or soft drink filling lines. In some instances, generally at captive two-piece beverage can plants, aluminum ends are made from precoated aluminum coil. A three-piece can plant visited during the preparation of this document fabricates aluminum ends from precoated aluminum strip;[6] a two-piece can plant that was visited purchases aluminum ends from other sources.[10]

With the exception of end-sealing operations, each of the coating operations is comprised of three emission points: coating application, flashoff area, and cure oven. Each end-sealing operation is comprised of two emission points, sealing application, and an area in which the ends are air dried.

The total VOC emitted per can or can end for each coating is a function of the coating thickness and the solvent and solids contents of the coating. The distribution of the total emissions among the three emission sources depends upon coating thickness, solvent content of the coating, type of solvent, ambient temperature, time and distance between the coater and the oven, and ventilation at the coater and between the coater and the oven. For each model case, total emissions per 1,000 cans or ends, are presented, based on the operating factors selected for each case.

When waterborne or low-solvent coatings are used without add-on controls, the distribution of emissions among the coater, flashoff area, and cure oven has no impact on total emissions from each coating operation because VOC from all emissions sources are discharged to the atmosphere. Distribution of emissions does have an impact on ventilating air required to maintain VOC concentrations at the work area at or below those specified by OSHA. When solvent-borne coatings and add-on emission control systems are used, distribution of emissions has an impact not only on ventilating air requirements, but also on requirements for capture and control of VOC emissions. Emission distributions used in base case and subsequent calculations are shown in Table 3-3.

Traditionally, insurance underwriters and oven standards[16] have required that flammable vapor concentrations not exceed 25 percent of the lower explosive limit (LEL) in oven air, as measured at the exhaust. Under current oven design criteria for installations using solvent-borne coatings, cure ovens are designed as if all of the VOC in the coating used would pass through the cure oven and an exhaust air flow rate set to result in 25 percent of LEL. The 25 percent of LEL is used because of energy requirements. A typical cure oven exhaust rate is 2,000 scfm. For waterborne coating,

TABLE 3-3. EMISSION DISTRIBUTIONS[11] [12] [13] [14] [15]
(percent)

Coating operation	Emission distributions	
	Coater and flashoff	Cure oven
Two-piece aluminum or steel cans		
Exterior base coat	75	25
Lithography/overvarnish	75	25
Inside spray	80	20
Sheet coating, three-piece steel cans		
Exterior base coat	10	90
Interior base coat	10	90
Cure oven	10	90
Inside spray, three-piece steel cans	80	20
Sheet coating, steel or aluminum ends		
Exterior coat	10	90
Interior coat	10	90

factors other than safety govern the exhaust rate, which results in relatively low VOC concentrations. Typical flow rates for cure ovens on beverage can lines using waterborne coatings are the same as for solvent-borne operations. When waterborne coatings are used, exhaust air flow is based on considerations other than percent of LEL. Sufficient air must pass through the oven to clear the VOC and compounds that may be formed during the curing process. In general, air flows are the same as for solvent-borne coatings.[17 18]

Maximum allowable concentrations and threshold limit values (TLV) have been established for organic solvent constituents customarily found in can coating systems. Most of the organic solvents used in major proportions in the coating systems have TLVs of 100 ppmv (parts per million by volume) or greater. The ventilating air at coater and flashoff have therefore been calculated on concentration rates of 100 and 500 ppmv VOC in the air. For each of the base cases, minimum ventilating air rates on this basis are presented per 1,000 cans or ends.

Another element of can coating cost relating to emissions is oven heat requirement, which also relates to ventilation. For each of the base cases, oven heat requirements are presented per 1,000 cans or ends. While oven heat and ventilation requirements differ for steel and aluminum cans, the difference is insignificant for equivalent coating weights. Therefore, energy requirements for aluminum cans have been used for the model plant analysis. It is recognized that coating thicknesses for steel cans are generally higher than for aluminum cans for the same container content. Additionally, coating thicknesses vary from use to use for either steel or aluminum. Consequently, the coating thicknesses shown in the model plant operating parameters were selected for analytical purposes.

In determining and selecting base case model operating factors for the calculation of emissions, minimum air flows, and relative oven heat requirements, reliance was placed on contacts with can industry representatives, coatings manufacturers, on can plant visits, and on published literature.[19 20 21 22] Various operating parameters are found in existing and newly constructed beverage can plants. Variations exist for each company, plant, customer, and product in sheet size, sheet base box weight (the weight in pounds of 31,360 square inches of sheet material), can body weight, coating composition, coating thickness, line speed, ventilation facilities, oven baking temperature and cycle, oven air circulation and exhaust practices, product mix, mechanical operating efficiency, and operating hours--in short, all operating factors. As a result, the base case plants are not patterned after any specific individual operating plant or plants. Rather, each of the operating factors selected for each of the cases was selected to be representative for that factor in new plants, based on interviews and plant visits, and each resulting base case is a composite based on the selected factors.

Several baseline operating factors, calculated emissions, calculated minimum air flow at coater and flashoff area, and calculated minimum cure oven exhaust and heat requirements are shown in Tables 3-4 and 3-5 for two-piece operations, in Tables 3-6 and 3-7 for three-piece can sheet coating. These factors are shown in Tables 3-8 and 3-9 for three-piece can forming, in Tables 3-10 and 3-11 for steel- or aluminum-end coating and in Tables 3-12 and 3-13 for end-sealing operations. Emissions, air flows, and heat requirements are expressed on the basis of 1,000 cans or ends. The emissions for various emission control options will be stated with respect to these base levels.

TABLE 3-4. MODEL PLANT OPERATING PARAMETERS, BASE CASE CTG WATERBORNE COATINGS: COATING OF BODIES FOR ALUMINUM AND STEEL, TWO-PIECE 12-OZ BEVERAGE CANS

	Exterior base coat	Lithography/ Overvarnish	Inside spray
Can body weight, lb/1,000 cans (aluminum/steel)	34/72	34/72	34/72
Dry coating weight, mg/can	400	120	200
Coating			
Volume-percent solids	25	25	17
Weight-percent solids	35	29	22
Weight-percent VOC	12	13	21
Weight-percent water	53	58	57
Specific gravity (kg/litre)	1.124	1.026	1.000
kg VOC/litre of solids	0.54	0.53	1.24
kg VOC/litre of coating, less water	0.34	0.34	0.51
Cure oven exit temperature, °F	400	400	400
Oven pin entering temperature, °F	200	200	
Oven conveyor entering temperature, °F			150
Ambient air temperature, °F	70	70	70

TABLE 3-5. MODEL PLANT COATING, VOC EMISSIONS, AND AIR FLOW PARAMETERS, BASE CASE CTG WATERBORNE COATINGS: COATING OF BODIES FOR ALUMINUM AND STEEL TWO-PIECE 12-OZ BEVERAGE CANS

	Emissions		Ventilating air acf per 1,000 cans		Cure oven[a]			
					acf per 1,000 cans		Btu per 1,000 cans	
	Distribution %	kg/1,000 cans	100 ppmv	500 ppmv	small scale	large scale	small scale	large scale
Exterior base coat								
Coater and flashoff	75	0.103	8,190	1,640	---	---	---	---
Cure oven	25	0.034	---	---	4,995	4,370	27,850	25,580
Total	100	0.137	8,190	1,640	4,995	4,370	27,850	25,580
Lithography/overvarnish								
Coater and flashoff	75	0.041	3,295	660	---	---	---	---
Cure oven	25	0.013	---	---	4,995	4,370	27,580	25,330
Total	100	0.054	3,295	660	4,995	4,370	27,580	25,330
Inside spray								
Coater and flashoff	80	0.161	13,930	2,585	---	---	---	---
Cure oven	20	0.040	---	---	4,995	4,370	25,160	22,910
Total	100	0.201	12,930	2,585	4,995	4,370	25,160	22,910
Total process								
Coater and flashoff		0.305	24,415	4,885	---	---	---	---
Cure oven		0.087	---	---	14,980	13,110	80,590	73,820
Total		0.392	24,415	4,885	14,980	13,110	80,590	73,820

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[a] Based on 700 cans/minute for small scale, 800 cans/minute for large scale.

TABLE 3-6. MODEL PLANT OPERATING PARAMETERS, BASE CASE, CTG WATERBORNE COATINGS: COATING OF STEEL BODY STOCK FOR THREE-PIECE 12-OZ BEVERAGE CAN

	Exterior base coat	Interior base coat	Lithography/ overvarnish
Sheet size, inches	35×42	35×42	35×42
Can bodies per sheet	35	35	35
Base box weight, lb	55	55	55
Dry coating weight, mg/in^2	10	2.5	2.5
Coating			
Volume-percent solids	25	25	25
Weight-percent solids	35	29	29
Weight-percent VOC	12	13	13
Weight-percent H_2O	53	58	58
Specific gravity (kg/litre)	1.124	1.026	1.026
kg VOC/litre of solids	0.54	0.53	0.53
kg VOC/litre of coating, less water	0.34	0.34	0.34
Cure oven exit[a] temperature, °F	400	400	400
Oven wicket entering temperature, °F	200	200	200
Ambient temperature, °F	70	70	70

[a] But before "cooling zone"

TABLE 3-7. MODEL PLANT COATING, VOC EMISSIONS, AND AIR FLOW PARAMETERS, BASE CASE, CTG WATERBORNE COATINGS: COATING OF STEEL BODY STOCK FOR THREE-PIECE 12-OZ BEVERAGE CANS

	Emissions		Ventilating air acf per 1,000 cans		Cure oven[a]			
					acf per 1,000 cans		Btu per 1,000 cans	
	Distribution %	kg/1,000 cans equivalents	100 ppmv	500 ppmv	small scale	large scale	small scale	large scale
Exterior base coat								
Coater-flashoff	10	0.014	1,165	233	---	---	---	---
Cure oven	90	0.123	---	---	1,905	1,560	11,670	10,940
Total	100	0.137	1,165	233	1,905	1,560	11,670	10,940
Interior base coat								
Coater-flashoff	10	0.005	382	76	---	---	---	---
Cure oven	90	0.040	---	---	1,905	1,560	10,460	9,730
Total	100	0.045	382	76	1,905	1,560	10,460	9,730
Lithography/Overvarnish								
Coater-flashoff	10	0.005	383	76	---	---	---	---
Cure oven	90	0.040	---	---	1,905	1,560	10,460	9,730
Total	100	0.045	383	76	1,905	1,560	10,460	9,730
Total process								
Coater-flashoff	10	0.024	1,930	385	---	---	---	---
Cure oven	90	0.203	---	---	3,330	2,730	32,590	30,400
Total	100	0.227	1,930	385	3,330	2,730	32,590	30,400

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[a] Based on 90 sheets/minute for small scale, 110 sheets/minute for large scale.

TABLE 3-8. MODEL PLANT OPERATING PARAMETERS, BASE CASE, CTG WATERBORNE COATINGS: COATING OF CAN BODIES FOR THREE-PIECE 12-OZ BEVERAGE CANS

	Inside spray
Can body weight, lb/1,000 cans	68
Dry coating weight, mg/can	200
Coating	
Volume-percent solids	17
Weight-percent solids	22
Weight-percent VOC	21
Weight-percent H_2O	57
Specity gravity (kg/litre)	1.000
kg VOC/litre solids	1.24
kg VOC/litre of coating, less water	0.51
Cure oven exit temperature, °F	400
Oven conveyor entering temperature, °F	150
Ambient temperature, °F	70

TABLE 3-9. MODEL PLANT COATING, VOC EMISSIONS, AND AIR FLOW PARAMETERS, BASE CASE, CTG WATERBORNE COATINGS: COATING OF CAN BODIES FOR THREE-PIECE 12-OZ BEVERAGE CANS

	Emissions		Ventilating air		Cure oven[a]			
	Distribution (%)	kg/1,000 cans	acf per 1,000 cans		acf per 1,000 cans		Btu per 1,000 cans	
			100 ppmv	500 ppmv	small scale	large scale	small scale	large scale
Inside spray								
Coater-flashoff	80	0.151	12,130	2,425	---	---	---	---
Cure oven	20	0.038	---	---	1,620	3,235	12,710	18,580
Total	100	0.189	12,130	2,425	1,620	3,235	12,710	18,580

[a] Based on 400 million cans per year for small scale, 800 million cans per year large scale.

TABLE 3-10. MODEL PLANT OPERATING PARAMETERS, BASE CASE, CTG WATERBORNE COATINGS: COATING OF STEEL- AND ALUMINUM-END SHEETS

	Exterior coating	Interior coating
Sheet size, inches	24 × 42	24 × 42
Ends per sheet	132	132
Base box weight, lb	118	118
Dry coating weight, mg/in^2	1.25	3.33
Coating		
Volume-percent solids	25	17
Weight-percent solids	29	22
Weight-percent VOC	13	21
Weight-percent H_2O	58	57
Specific gravity (kg/litre)	1.026	1.00
kg VOC/litre solids	0.53	1.24
kg VOC/litre of coating, less water	0.34	0.51
Ambient air temperature, °F	70	70
Oven wicket entering temperature, °F	200	200
Cure oven exit temperature, °F	400	400

TABLE 3-11. MODEL PLANT COATING, VOC EMISSIONS, AND AIR FLOW PARAMETERS, BASE CASE, CTG WATERBORNE COATINGS: COATING OF STEEL- AND ALUMINUM-END STOCK

	Emissions		Ventilating air (acf per 1,000 ends)		Cure oven	
	Distribution (%)	kg/1,000 ends	100 ppmv	500 ppmv	acf per 1,000 ends	Btu per 1,000 ends
Exterior coating						
Coater-flashoff	10	0.0004	330	66	-	-
Cure oven	90	0.0037	-	-	294	2,330
Total	100	0.0041	330	66	294	2,330
Interior coating						
Coater-flashoff	10	0.0016	1,270	254	-	-
Cure oven	90	0.0142	-	-	295	8,980
Total	100	0.0158	1,270	254	295	8,980
Total process						
Coater-flashoff	10	0.0020	1,600	320	-	-
Cure oven	90	0.0179	-	-	589	11,310
Total	100	0.0199	1,600	320	589	11,310

TABLE 3-12. MODEL PLANT OPERATING PARAMETERS, BASE CASE, CTG END-SEALING COMPOUND: STEEL AND ALUMINUM ENDS[23 24]

End-sealing compound	
Volume-percent solids	44
Weight-percent solids	53
Weight-percent VOC	47
Weight-percent H_2O	-
Specific gravity (kg/litre)	0.948
kg VOC/litre of solids	1.01
Wet end-sealing compound applied	
mg/end, aluminum	150
mg/end, steel	230

TABLE 3-13. MODEL PLANT COATING, VOC EMISSIONS AND AIRFLOW PARAMETERS, BASE CASE: APPLICATION OF END-SEALING COMPOUND[2]

	Emissions	Ventilating air acf per 1,000 ends	
	kg/1,000 ends	100 ppv	500 ppv
Aluminum ends	0.71	5,700	1,140
Steel ends	0.108	8,050	1,735

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4. EMISSION CONTROL TECHNIQUES

This chapter describes and evaluates emission control techniques applicable to the beverage can surface coating industry. The purpose of these control techniques is to reduce emissions of volatile organic compounds (VOCs) to the air. These compounds, which include ketones, alcohols, esters, saturated and unsaturated hydrocarbons, and ethers, are used for coatings, thinners, and cleaning materials in industrial finishing processes.

Several types of control techniques are presently in use in either the beverage can surface coating industry or in related industries. These methods can be categorized as either add-ons or new coating systems. Add-ons are pollution control equipment used to reduce emissions by recovering or destroying solvents before they are emitted to the air. The elimination of a coating operation; i.e., base coat or overvarnish, is also a viable option for the reduction of VOC emissions in those instances where customer performance requirements can be met without the coat.

New coatings may contain reduced quantities of VOC compared to traditional solvent-borne materials. In other instances some part of the VOC content may be incorporated into the finish by polymerization. With the exception of powder and electrodeposition coatings, new coatings can generally be applied with existing equipment. Examples of industrial finishing processes that use new coatings are roll, mandrel or spray application of waterborne coatings, spray of powder materials, and roll or mandrel application of high solids and UV-curable coatings.

Because of their generally lower organic solvent content, new coating materials used in place of conventional solvent-borne coatings in industrial finishing processes can result in substantial reductions in VOC emissions.

4.1 ALTERNATIVE EMISSION CONTROL TECHNIQUES

4.1.1 Waterborne Coatings

The use of waterborne coatings is the most common control technique presently in use in the beverage can surface coating industry. It reportedly accounted for 80 percent of all low-solvent "compliance coatings" used by the can industry in 1977.[1] One estimate placed waterborne coating consumption for the entire can market at approximately 11 million litres (3 million gallons) during 1977.[2]

Nearly all waterborne coatings used by the can industry are for beverage cans. In 1977, 12 percent of the approximately 95 million litres (25 million gallons) of coatings consumed by the beverage can segment were waterborne. Other estimates place waterborne coatings at between 15 and 25 percent of total coatings use during 1978 for beverage cans.[3] [4] [5]

Waterborne coatings are used in the beverage can industry for base coats, inside sprays, and overvarnishes.[6] [7] Both clear (unpigmented) and opaque (pigmented) coatings are used on beverage cans. Overvarnishes are generally used for clear base coats. Only a small segment of the beverage can industry uses clear base coats. One merchant canmaker reports that less than 2 percent of base coats used are clear.[8]

The term waterborne as used in this report refers to any coating which uses water rather than organic solvents as the primary carrier. The volatile portion of the waterborne coating generally contains 70 to 80 volume-percent water.

Waterborne coatings are attractive to the can industry for several reasons. They generally can be applied with existing equipment, with little or no modification.[9]

The various coatings that are applied to beverage cans--inside sprays, base coats, overvarnishes, etc.--have narrow specific requirements. All of these can be met with presently available waterborne coatings.[10]

The emission of volatile organics from waterborne coatings depends on the solvent-to-solids ratio in the paint, the film thickness applied, the surface area of the parts to be coated, and the number of units finished per hour.

End-sealing compounds currently in use are solvent-based materials, most of which do not meet the emission limitations recommended in the CTG. Processes are underway to assess the suitability of solvent-based compounds satisfying the emission limitations recommended in the CTG and water-based compounds in which the carrier contains no VOC.

4.1.1.1 Waterborne Spray. In the beverage can industry, waterborne spray coatings are used in place of traditional solvent-borne materials for inside sprays for beer and soft drink cans.[6 7 11] One can manufacturer estimated that in 1978 over 7.5 million litres (2 million gallons) of waterborne spray coating would be used for the interior of two-piece cans alone.[12] One coatings manufacturer estimated that in 1978 as much as 15 percent of the two-piece beverage can market was using waterborne coatings for inside sprays.[5]

The first waterborne inside spray was introduced in early 1975.[5] Most waterborne inside sprays in current use are based on either acrylic or epoxy,[5 13] and are typically applied at approximately 20 weight-percent solids from an 80/20 volume-percent waterborne carrier.[6 7 14] One coating supplier provides an inside spray coating with 21.6 weight-percent solids that accounts for more than 75 percent of the waterborne usage.[15] These coatings are applied to both two-piece and three-piece cans without the use of special equipment.[1 16]

Airless spray is the preferred application method, although air spray is still used for older three-piece can lines. Dry coating weights are comparable to those applied with conventional solvent-borne sprays, generally 0.4 to 1.2 mg/cm^2 (2.5 to 8 mg/in^2), depending on whether the coating is for beer or soft drinks, for steel or aluminum, or for two- or three-piece cans.[6 17 18]

Curing requirements for waterborne coatings are generally comparable to those for solvent-borne coatings. It is rarely necessary to increase oven temperatures and/or stay time to accommodate waterbornes.

4.1.1.2 Waterborne Mandrel Coating. Mandrel coating is the method used to apply exterior base coat and overvarnish to two-piece cans. It should be noted that some two-piece can makers eliminate exterior base coat and/or overvarnish.

Mandrel-applied waterborne exterior base coats for two-piece cans have been in use since the mid-1970's. Today, approximately 20 percent of the exterior base coating for two-piece cans is waterborne.[5] It was estimated that in 1978 approximately 3 million litres (800,000 gallons) of waterborne base-coating material was used for two-piece cans,[19] representing approximately 20 percent of the roughly 15 million litres (4 million gallons) of base coating used by this segment of the beverage can coating industry.[5]

While current use of waterborne overvarnish is not as widespread as use of waterborne exterior base coat, such varnishes have been commercially used for two-piece cans since 1974. Consumption of waterborne varnish for two-piece cans has been estimated at approximately 1.1 million litres (300,000 gallons) for 1977.[19]

Conversion from solvent-borne coatings to waterborne materials requires only minor equipment modifications, such as replacement of lines and pumps with components constructed from corrosion-resistant materials such as stainless steel.[1 9] Most of the waterborne base-coating materials are either acrylics or polyesters and are applied at between 50 and 60 weight-percent solids.[4 15 18] The solvent content of these base coats is generally between 20 and 30 volume percent of the volatile portion of the coating, but efforts are being made to lower this proportion.[5 18] One coating on the market contains 42.6 volume-percent (56.6 weight-percent) solids, 19.5 weight-percent VOC, and 33.9 weight-percent H_2O.[20] Coating weights for waterborne base coatings for two-piece cans are generally comparable to those applied with solvent systems, approximately 300 mg/can for aluminum and 350 to 500 mg/can for steel.[6 9 21 22]

Overvarnishes must be compatible with lithographic inks and be scuff resistant. Most waterborne varnishes for two-piece cans are based on either polyester or acrylic and are applied at between 32 and 38 weight-percent solids (27.6 and 33.2 volume-percent solids).[4 23] One coating on the market contains 34.7 volume-percent (37.9 weight-percent) solids, 14.9 weight-percent VOC, and 47.2 weight-percent H_2O.[24] Coating weights for waterborne overvarnishes are generally comparable to those applied with solvent-borne coatings and range from 120 to 150 mg/can.[21 25]

4.1.1.3 Waterborne Roll Coating. Waterborne coatings are used for three-piece cans, but not as extensively as for two-piece cans. Waterborne roll coating is being used to a limited extent on sheets for three-piece can bodies for base coats, overvarnish, and exterior end coat. Annual consumption of waterborne coatings for three-piece cans has been estimated at approximately 2.6 million litres (700,000 gallons).[19]

Waterborne white base coats containing modified acrylic resins have been used commercially for three-piece cans since 1976. One factor which may have delayed acceptance of these materials for this application has been poor adhesion to tin-free steel plate. This may be because plates are generally not pretreated in the plant, but are received pretreated. They may contain small quantities of lubricant to facilitate feeding into the coater and the presence of this lubricant may be the cause of inadequate wetting and adhesion.

Roll-coated waterborne varnishes are also used commercially on a limited basis. These coatings typically contain 30 to 36 weight-percent solids (25.7 to 31.3 volume-percent solids) with 20 volume-percent VOC in the volatile portion of the material.[18 26] One factor which has limited the use of waterborne wet ink varnishes for three-piece cans has been incompatibility between the varnishes and the lithographic inks,[27] and the increasing use of no-var inks (inks not requiring overvarnish).

Roll-coated waterborne exterior end coatings have also been commercialized. Formulated for optimum scuff resistance, these coatings are generally based on epoxy, polyester, or modified acrylics.[27]

4.1.1.4 Electrodeposition. There is presently no indication that electrodepostion is used commercially for coating beverage cans. Major can and coatings manufacturers, however, hold patents on processes for applying inner lacquers by electrodeposition, along with companion patents covering waterborne lacquer for use in the electrodeposition process.[28 29 30] In this process, an aqueous dispersion is fed into inverted can bodies. The can is made the anode of the system, and coating is electrodeposited onto the inside. The process is similar to both flow coating and electrocoating.[31]

One company has two prototype machines in the late stages of engineering. Pilot runs with a line speed of 300 cans/minute were scheduled for early 1979.[31] According to the inventor, the equipment is potentially scalable to normal production speeds of 800 to 1,000 cans/minute. The process is capable of applying coatings as thin as 1 mg/in^2, and coated cans have reportedly received approval from two breweries, based on preliminary pack tests.[32]

4.1.1.5 Ultraviolet-Cured Coatings. A new technology that has received a great deal of attention over the past 10 years is UV curing, a radiation-initiated polymerization for curing industrial finishes and printing inks. This technology has been used for "drying" inks in the beverage can industry.

UV-curable coating materials are 100 percent convertible to solids, that is, they contain essentially no residual volatile organic compounds. As a result, they offer substantial reductions in the emission of volatile organic compounds (VOC) over conventional solvent-borne coatings. UV-curable coatings generally fall into two major types, unsaturated polyester/styrene systems, and acrylic systems.

A third type of UV coating, developed by one of the major can companies, employs epoxy resins in combination with a photoreactive curing agent that cures the epoxy much like a conventional epoxy coating.[33] This system is receiving little commercial use.

UV-curable overvarnish is used for approximately 10 percent of the three-piece beverage can markets. Very little, if any, use is reported for two-piece cans.[34]

Several factors have deterred the use of UV-cured overvarnish:[35] [36]

- Cost of the coating, which ranges between \$6.60 and \$7.90 per litre (\$24 to \$30 per gallon).
- Application problems. Thickness is difficult to control with available application equipment, and flow and leveling are poor compared to conventional materials.
- Monomer toxicity.

One major can company, although directing most of its efforts in UV cure towards flat-sheet lithography, has been investigating overvarnishes. A photocurable epoxy has been used as a dry ink varnish over millions of printed sheets for nonfood applications such as aerosol cans, and for both aluminum and tin-free steel beverage can ends.[37] [38] In addition, a line was recently started for the application of UV-cured acrylic wet ink varnish for two-piece cans. The bottom-rim varnish on this line is also UV cured.[38]

While UV-cured white base coats have been considered, there is no evidence of commercial use of this technology in the beverage can industry.[39] One major can company claims to be working on such a material, but at present does not have a commercial coating.[38]

4.1.1.6 High-Solids Coatings. High-solids coatings contain at least 80 volume-percent solids.[40] Contact with beverage can manufacturers during the development of this document did not uncover any high-solids coatings in use in recently constructed beverage can lines or planned for use in the near future.[41] [42] [43] [44] [45] [46] [47]

4.1.1.7 Powder Coatings. While a powdered epoxy spray process and materials suitable for applying inside lacquer coatings to beverage cans has been developed by one coating company,[48] contacts with beverage can manufacturers during the development of this document did not uncover any use of powder coatings in recently constructed beverage can lines in use or planned for use in the near future.[43] [44] [45] [46]

4.1.1.8 End-Sealing Compounds. Practically all of the end-sealing compound used by the beverage can industry is solvent-based. Little, if any, used today has a VOC content that would meet the emission limitation recommended in the CTG. Research and development is being conducted on new higher solids solvent-based and water-based compounds that would result in emissions which are equal to or less than the recommended emission limitation.[49] [50] [51] [52]

The leading supplier of beverage can end-sealing compound is currently not offering a compound that meets the CTG-recommended emission limitation, projecting that such compounds will be available by 1982.[49] Another supplier, representing most of the remaining market, introduced a solvent-based CTG-compliance end-sealing compound in 1979, and is currently working on a second-generation model with a higher solids and a lower VOC content. The compliance material is being tested by a major soft drink producer.[51]

A major brewery is currently evaluating ends lined with solvent-based end-sealing compounds supplied by two merchant can manufacturers. Ends made by one canmaker are in the final stage of clearance.[53]

Considerable attention is being given to the development of water-based end-sealing compounds. These materials, which contain no or only a negligible amount of VOC, are formulated to be air dried and do not require oven or forced air drying.[49] [50] [52] Test runs were initially satisfactory. However, problems developed that resulted in temporary discontinuance of the tests. One producer of beverage can ends found the water-based materials to be satisfactory during the winter months but experienced problems when the ends were shipped to and stored in a hot humid environment.[54] [55] A major canmaker states as its goal to eventually be totally dependent on water-based end-sealing compounds. However, the determining factor is customer acceptance. To that end, canmakers are engaged in a program to qualify water-based end-compounds with their customers, who are performing functional and taste tests to determine which, if any, of the available compounds are acceptable. Qualification testing of new end-sealing compounds is a lengthy process and may take as long as 18 months after a new compound becomes available.[56]

While water-based end-sealing compounds require only air drying, some canmakers feel it necessary to heat dry by forced-air drying.[51] [52] Under some circumstances, e.g., high humidity, the evaporation of moisture after packaging of the ends may result in the accumulation of sufficient moisture in the paper sleeves that they break open during handling. To preclude this, some installations may include a small hot air dryer in the end line prior to packaging. At this time, it is not known if a drier is required on all installations.[50]

A major captive canmaker is engaged in an aggressive program to evaluate ends lined with water-based end-sealing compounds. While some problems are being experienced, they are considered solvable as the industry gains experience in the use of water-based end-sealing compounds. The water adsorption problem could be ameliorated by reducing to a minimum the time that ends are in the immediate vicinity of the filling line.[56]

4.1.1.9 No-Var Inks. According to one ink manufacturer, approximately half of all two-piece beverage cans use no-var inks in place of conventional inks plus overvarnish.[57] No-var inks also exist for three-piece cans. No-var inks are specially formulated inks that provide the desired surface characteristics without the use of an overvarnish.[37] No-var ink eliminates an added coating step and resulting VOC emissions. One can manufacturer has discontinued the use of no-var inks for two-piece cans because the increased friction was found to be detrimental to high-speed can manufacturing and filling lines.[58]

No-var inks are usually applied over clear or white exterior base coats, but at least one beverage can manufacturer is applying no-var inks directly over freshly cleaned aluminum.[6] Most no-var inks are thermally curable and are applied by dry offset printing, at weights comparable to the conventional inks that they are replacing.

No-var inks may not meet the specifications for gloss and scuff resistance that have been set up by some beverage-can customers. In such cases, can manufacturers apply overvarnish.

During 1979 there was a trend away from no-var inks. One merchant canmaker reports a decrease in the use of no-var inks and UV-curable overvarnishes from 80 percent in 1979 to 5 percent in the early part of 1980.[59]

4.1.2 Add-on Emission Control Systems

Incineration is the most universally used add-on emission control system for VOC emissions from industrial processes. It is used throughout the industrial finishing industry, but only to a limited extent in the beverage can coating industry, where both noncatalytic (thermal or direct fired) and catalytic units are in evidence.[26 60 61 62]

4.1.2.1 Thermal Incinerators. Direct-fired afterburners operate by heating solvent-laden air to near its combustion temperature and then bringing it in direct contact with a flame. In general, high temperature and high organic concentration favor combustion; a temperature of 760° C (1,400° F) sustained for 0.5 second is normally sufficient for nearly complete combustion.

Because the solvent emissions are below the combustible limit, auxiliary heating of the air is necessary for incineration. The quantity of heat to be supplied depends on the temperature of the incoming air stream and the concentration of the organic in the air stream. The higher the concentration, the lower the auxiliary heat requirement, because of the fuel value of the organic materials. To reduce the cost of thermal incineration, heat-transfer devices are used to recover at least part of the heat of combustion.[59 63 64]

Thermal incinerators are in use on several can coating lines for both two- and three-piece beverage cans.[26 59 60] At the present time, most are used to control emissions from bake ovens. One coater is using thermal incineration to control emissions from inside spray coaters and flashoff areas as well. He reports, however, that the line will be converted to waterborne coatings because of recent increases in the cost of natural gas.[65] Although individual afterburner units can be used, in many cases the exhaust from several ovens is ducted into one common incinerator.[59 60]

Operating temperatures are generally in the range of 650° to 815° C (1,200° to 1,500° F). Heat recovery is used with some units, with recovery as high as 50 percent.[26 60]

4.1.2.2 Catalytic Incineration. This add-on emission control system makes use of a metal catalyst to promote or speed combustion of volatile organic compounds. Oxidation takes place at the surface of the catalyst to convert organics into carbon dioxide and water.[66 67] The catalysts, usually noble metals such as platinum and palladium, are supported in the hot gas stream so that a high surface area is presented to the waste organics. A variety of designs are available for the catalyst, but most units use a noble metal deposited on a high area support, such as ceramic rods or honeycomb or alumina pellets.[66 67 68]

As with thermal incinerators, the performance of the catalytic unit is dependent on the temperature of the gas passing across the catalyst and the residence time and the type of organic being oxidized.[68]

Use of a catalyst permits lower operating temperatures than are used in direct-fired units. Temperatures are normally in the range of 260° to 320° C (500° to 600° F) for the incoming air stream, and 400° to 540° C (750° to 1,000° F) for the exhaust. The exit temperature from the catalyst depends on the inlet temperature, the concentration of organic, and its heat of combustion.

Primary and secondary heat recovery can be used to minimize auxiliary fuel requirements for the inlet air stream and to reduce the overall energy needs for the plant. Although catalysts are not consumed during chemical reaction, they gradually lose their effectiveness in burning the organics. This deterioration is caused by poisoning with chemicals such as phosphorous and arsenic, which react with the catalyst; by coating the catalyst with particulates or condensates; and by high operating temperatures. In most cases, catalysts are guaranteed for 1 year by the equipment supplier,[69] but with proper filtration, cleaning, and attention to moderate operating temperatures, the catalyst should have a useful life of 2 to 3 years.[66 69 70]

Catalytic incineration is currently used in the beverage can coating industry only for oven emissions.[60] Typical operating temperature is 310° to 430° C (600° to 800° F).[60]

4.1.2.3 Carbon Adsorption. While adsorbers are not currently used in the beverage can coating industry, they have been used successfully in other finishing industries.[71 72 73]

One major beverage can manufacturer had installed a carbon absorption unit at one plant, but after 3 years effort to make the unit work dependably, concluded that carbon adsorption was not a viable control option. Problems of carbon adsorption enumerated by the company include added fuel requirements, requirement for extra control to remove organic tar-like residues prior to adsorption, short carbon life, removal of water-miscible solvents from the steam condensate discharge, and corrosion of the adsorber tank and carbon bed supporting screen.[74]

4.2 VIABLE EMISSION CONTROL OPTIONS

Emissions can be controlled through the use of either new coatings, or add-on emission control systems. Add-ons ordinarily destroy the organic solvent emissions. New coatings contain a lower amount of volatile organic material than traditional coatings.

While the trend in the beverage can industry is away from solvent-borne and toward waterborne coatings, solvent-borne coatings may continue to be used for new, modified or reconstructed facilities.[46] Therefore incineration, either in a new facility or as an add-on to a modified or reconstructed existing facility, must be considered a viable control option. Field investigations indicate that both thermal and catalytic incineration are capable of removing at least 90 percent of the solvents captured from exhaust air streams.[75]

While there may be some use of solvent-borne coatings with add-on controls, waterborne coatings will dominate new can lines and modified or reconstructed existing lines. VOC contents of waterborne coating with lowest VOC content in general use are shown in Table 4-1. VOC contents of solvent-borne coatings identified as the highest solid content in general use are shown in Table 4-2.

TABLE 4-1. VOC CONTENT OF WATERBORNE COATINGS WITH LOWEST VOC CONTENT IN GENERAL USE[8 15 20 24 59 76]

Coating operation	VOC content	
	kg VOC per litre of solids	kg VOC per litre of coating, less water
Two-piece cans		
Exterior base coat, except clear	0.29	0.22
Overvarnish and clear base coat	0.46	0.30
Inside spray	0.89	0.43
Three-piece cans		
Exterior base coat	0.50	0.32
Interior base coat	0.50	0.32
Overvarnish	0.46	0.30
Inside spray	0.64	0.36
Steel and aluminum end sheets		
Exterior coat	0.50	0.32
Interior coat	0.50	0.32
End-sealing application[a]	0.05	0.05

[a] Currently undergoing qualification tests.

TABLE 4-2. VOC CONTENT OF HIGHER SOLIDS SOLVENT-BORNE COATINGS IN GENERAL USE[5 77][a]

Coating operation	kg VOC per litre of solids	kg VOC per litre of coating, less water	Overall control efficiency equivalent to waterborne
Two-piece cans			
Exterior base coat	1.00	0.45	71
Overvarnish	2.55	0.64	82
Inside spray	3.01	0.66	70
Three-piece cans			
Exterior base coat	1.00	0.45	50
Interior base coat	3.30	0.72	85
Overvarnish	1.47	0.54	69
Inside spray	3.01	0.66	79
Steel and aluminum end sheets			
Exterior coat	1.04	0.47	52
Interior coat	3.30	0.72	85
End-sealing application[b]	1.07	0.43	95

[a] Average of coatings used by a major canmaker.

[b] Currently undergoing qualification tests.

UV-cure overvarnish and no-var inks are considered viable alternative control options for the use of solvent-borne overvarnish followed by incineration, or for the use of waterborne overvarnish.

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5. MODIFICATION AND RECONSTRUCTION

Under section 111 of the Clean Air Act of 1970, emission standards may be established for new stationary sources. The New Source Performance Standards (NSPS) apply to affected facilities which are located primarily at newly constructed plants in certain source categories. An affected facility may be defined as a single emission point, a group of emission points, a line, or an entire plant.

NSPS can also apply to existing facilities that are modified or reconstructed. Provisions applicable to modifications and reconstructions appear in the Code of Federal Regulations (40 CFR 60), "Environmental Protection Agency Regulations on Standards of Performance for New Stationary Sources," under Subpart A, "General Provisions," Sections 60.14 and 60.15.

5.1 MODIFICATION

Modification is defined in 40 CFR as "any physical change in, or change in the method of operation of, an existing facility which increases the amount of any air pollutant (to which a standard applies) emitted into the atmosphere by that facility or which results in the emission of any pollutant (to which a standard applies) into the atmosphere not previously emitted." For purposes of modification emissions are measured in terms of kilograms per hour.

In certain circumstances, however, such changes are not considered modifications. If, for example, the change is made to increase the production rate of an existing facility within design rates and does not involve a capital expenditure on the stationary source containing that facility, it is not considered a modification. A capital expenditure is an amount more than the current annual asset guideline repair allowance, which is calculated using the rates for various industries tabulated in Internal Revenue Service Publication 534.

There are other exceptions to the definition of modification. In a beverage can plant, simply increasing the line speed (cans per minute) within design limits does not constitute a modification. Increasing actual operating hours by running three shifts rather than two per day, or extending 8-hour shifts to 10, also is not a modification. In addition, routine repair, maintenance, and replacement of worn parts in a facility are not modifications.

According to 40 CFR 60.14(3)(4), use of an alternate raw material does not constitute a modification if it can be demonstrated that the existing facility was designed to accommodate that alternative use. Therefore, the use of alternative coating materials which would increase emissions, would not be a modification if the existing facility was designed to use these materials. Such changes are not likely to occur.

If a change to a can coating line involved the installation of equipment primarily to reduce solvent emissions, this change would not be a modification.

Other possible changes that could result in increased VOC emissions include:

- Change to Larger Cans. If can sizes were increased and the same production rates were maintained, more coating materials would be used and more solvents would be emitted. This would occur if a line producing two-piece 12-ounce beverage cans were converted to the production of 16-ounce cans. Many facilities are designed to permit routine changes of can size.[1]

- Change to Thicker Coatings. A change to a thicker coating, if other factors remain constant, could result in increased solvent emissions. For example, changing from production of two-piece aluminum cans for malt liquor to two-piece aluminum cans for soft drink use would require the application of a thicker inside spray coating. Changing from two-piece aluminum to two-piece steel would require the application of a thicker exterior base coat. Both of these examples result in increased coating use and consequently increased solvent emissions. In merchant can plants, the ultimate users of the cans may require different coating thickness. Thus, the canmaker would be required to change the thickness of coating applied or production lots change. Within design limits of the can line, these changes require only an adjustment to the coater.

- Additional Coating Stations. If for any reason one or more coating stations were added, emissions would be increased. For example, for aluminum two-piece cans for soft drinks, the inner lacquer is deposited in one application, while for steel two-piece cans, the lacquer is generally applied in two coats. When a line is converted from aluminum to steel cans, additional stations might be required for the inside spray coat. In some instances the additional spray station may have been built into the line.

5.2 RECONSTRUCTION

While modification refers to comparatively minor changes in a facility or its method of operation, which result in an increase in emissions, reconstruction refers to a substantial change in an existing facility, regardless of change in emission rate. As with a modified facility, a reconstructed existing facility, by definition, becomes an affected facility and subject to NSPS.

A reconstructed facility is defined as one in which:

- The fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility, and
- It is technologically and economically feasible to meet the standards.

Roll and mandrel coaters, spray units, and ovens used in coating beverage cans generally last more than 20 years[2] [3] [4] [5] and are not replaced before that time unless process changes dictate it. In some cases, a line may be moved to another location within a plant and ovens may deteriorate, requiring some rebuilding. Ultimately, however, worn out or obsolete units must be replaced, and such changes, if they meet the above requirements, qualify as reconstructions.

Ovens could be replaced with more efficient models using recirculating inert air[6] or alternate energy sources, such as oil or electricity. Again, this would be considered a reconstruction if the above requirements were met.

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6. MODEL PLANTS AND REGULATORY ALTERNATIVES

This chapter presents a number of regulatory alternatives that will be used in analyzing the range of environmental impacts (Chapter 7) and economic impacts (Chapter 8) associated with the control of VOC emissions from the beverage can surface coating industry. Individual emission control technologies applicable to can surface coating operations are described and evaluated in Chapter 4.

An emission control system can be either a coating material and application technique, an add-on control device, or a combination of the two. The choice of systems depends on the particular coating operation and the degree of control desired.

Cans are made in one of two ways. The "two-piece" can is drawn and wall-ironed from a shallow steel or aluminum cup and requires only one aluminum end, which is attached after the can is filled with a product. Forming and coating of two-piece cans are accomplished under one roof. The aluminum ends may be made at a separate plant.

"A "three-piece" can is made from a rectangular sheet (body blank) and two circular ends. The metal sheet is rolled into a cylinder and soldered, welded, or cemented at the seam. One end is attached during manufacturing, the other during packaging of the product. The body blanks and the end stock may be coated at one facility and formed into can bodies and ends at another. In some cases the ends themselves may be made at a separate facility. The can body and the bottom ends are made of tinplate steel or tin-free steel. The top is made of aluminum.

6.1 MODEL PLANTS

Because of the nature of the industry and the possible fragmentation of three-piece can facilities, five sets of model plants are considered appropriate. Coating formulations and emission data for the model plants are presented in Tables 6-1 through 6-4 and operating parameters in Tables 6-5 and 6-8. The following coating operations are considered:

Two-piece aluminum- and steel-can integrated facility (Tables 6-1) and 6-6)

- Exterior base coat
- Lithography and overvarnish
- Inside spray (2 applications for steel cans)

Three-piece steel-sheet coating (Tables 6-2 and 6-7)

- Exterior base coat
- Interior base coat
- Lithography and overvarnish

Three-piece steel-can forming (Tables 6-3 and 6-8)

- Inside spray

Steel- and aluminum-end sheet coating (Tables 6-4 and 6-9)

- Exterior base coat
- Interior base coat

Steel- and aluminum-end forming (Tables 6-5 and 6-10)

- End-sealing application

Although there are many alternatives for controlling emissions from can surface coating operations, the alternatives shown in Tables 6-1 through 6-4 are considered representative and only these options are applied to the model plants.

Model plant extensive parameters, presented in Tables 6-1 through 6-10 with emission rates based on 1,000 cans or ends produced, are independent of production rate. Except for the application of end-sealing compound, emissions from these plants are further classified as coming from the coater-flashoff area and cure oven.

Descriptions of the model plants follow.

6.1.1 Two-Piece Beverage Cans

While each coating and forming line is a complete facility in itself, more than one line are usually found within a beverage can plant. Recently constructed two-piece can plants have contained two to six lines.[1] [2] [3] [4] [5]

Two sizes of plants are presented for analyzing the economic impact of regulatory alternatives for the control of VOC emissions from two-piece beverage can plants.

TABLE 6-1. CAN SURFACE COATING, TWO-PIECE ALUMINUM- AND STEEL-INTEGRATED FACILITY EVALUATION OF EMISSION CONTROL OPTIONS

Option	Coating operation	Emission control system: Coating	Emission control system: kg VOC per litre of coating solids	Incineration requirements	VOC kg/1,000 cans	% reduction from base case
Base case	Exterior base coat	Waterborne	0.54	None	0.137	--
	Lithography/overvarnish	Waterborne	0.53	None	0.054	--
	Inside spray	Waterborne	1.24	None	0.201	--
	Total				0.392	--
Option IA	Exterior base coat	Solvent-borne	1.00	Cure oven and coater[a]	0.076	45
	Lithography/overvarnish	Solvent-borne	2.55	Cure oven and coater[a]	0.073	(35)
	Inside spray	Solvent-borne	3.01	Cure oven, coater, flashoff[a]	0.086	57
	Total				0.235	40
Option IB	Exterior base coat	Solvent-borne	1.00	Cure oven and coater[a]	0.076	45
	Lithography/overvarnish	No-varnish inks	-	None	0.005	91
	Inside spray	Solvent-borne	3.01	Cure oven, coater, flashoff[a]	0.086	57
	Total				0.167	57
Option IC	Exterior base coat	Waterborne	0.29	None	0.073	46
	Lithography/overvarnish	Waterborne	0.46	None	0.046	13
	Inside spray	Waterborne	0.89	None	0.148	29
	Total				0.267	32
Option ID	Exterior base coat	Waterborne	0.29	None	0.073	46
	Lithography/overvarnish	No-varnish inks	-	None	0.005	91
	Inside spray	Waterborne	0.89	None	0.148	29
	Total				0.226	42

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[a] Incinerator efficiency 90 percent; capture efficiency, cure ovens 100 percent; coater 90 percent; flashoff for inside spray 80 percent.

TABLE 6-2. CAN SURFACE COATING, THREE-PIECE STEEL-SHEET COATING EVALUATION OF EMISSION CONTROL OPTIONS

		Emission control system				
Option	Coating operation	Coating	kg VOC per litre of coating solids	Incineration requirements	VOC kg/1,000 cans	% reduction from base case
Base case	Exterior base coat	Waterborne	0.54	None	0.142	--
	Interior base coat	Waterborne	0.53	None	0.046	--
	Lithography/overvarnish	Waterborne	0.53	None	0.046	--
	Total				0.234	
Option IIA	Exterior base coat	Solvent-borne	1.00	Cure oven, flashoff, coater[a]	0.030	79
	Interior base coat	Solvent-borne	3.30	Cure oven, flashoff, coater[a]	0.029	37
	Lithography/overvarnish	Solvent-borne	1.47	Cure oven, flashoff, coater[a]	0.014	70
	Total				0.073	69
Option IIB	Exterior base coat	Solvent-borne	1.00	Cure oven, flashoff, coater[a]	0.030	79
	Interior base coat	Solvent-borne	3.30	Cure oven, flashoff, coater[a]	0.029	37
	Lithography/overvarnish	No-varnish inks or UV cure	-	None	0.005	89
	Total				0.064	73
Option IIC	Exterior base coat	Waterborne	0.50	None	0.131	8
	Interior base coat	Waterborne	0.50	None	0.044	4
	Lithography/overvarnish	Waterborne	0.46	None	0.040	13
	Total				0.215	8
Option IID	Exterior base coat	Waterborne	0.50	None	0.131	8
	Interior base coat	Waterborne	0.50	None	0.044	4
	Lithography/overvarnish	No-varnish inks or UV cure	0.46	None	0.005	89
	Total				0.180	23

[a] Incinerator efficiency 90 percent; capture efficiency; cure ovens 100 percent; coater and flashoff 90 percent.

TABLE 6-3. CAN SURFACE COATING, THREE-PIECE CAN FORMING LINES: EVALUATION OF EMISSION CONTROL OPTIONS

		Emission control system				
Option	Coating operation	Coating	kg VOC per litre of coating solids	Incineration requirements	VOC kg/1,000 cans	% reduction from base case
Base case	Inside spray	Waterborne	1.24	None	0.207	--
Option IIIA	Inside spray	Solvent-borne	3.01	Cure oven, coater, flashoff	0.086	59
Option IIIB	Inside spray	Waterborne	0.64	None	0.107	48

[a] Incinerator efficiency 90 percent; capture efficiency, cure ovens 100 percent; coater and flashoff 90 percent.

TABLE 6-4. CAN SURFACE COATING, ALUMINUM- AND STEEL-END SHEET COATING: EVALUATION OF EMISSION CONTROL OPTIONS

Option	Coating operation	Emission control system		Incineration requirements	VOC kg/1,000 ends	% reduction from base case
		Coating	kg VOC per litre of coating solids			
Base case	Exterior coating	Waterborne	0.53	None	0.0042	--
	Interior coating	Waterborne	1.24	None	0.0263	--
	Total				0.0305	--
Option IVA	Exterior coating	Solvent-borne	1.04	Cure oven	0.0016	62
	Interior coating	Solvent-borne	1.30	Cure oven	0.0121	54
	Total				0.0137	55
Option IVB	Exterior coating	Waterborne	0.50	None	0.0040	5
	Interior coating	Waterborne	0.50	None	0.0105	60
	Total				0.0145	53

[a] Incinerator efficiency 90 percent; capture efficiency, cure ovens 100 percent; coater and flashoff 80 percent.

TABLE 6-5. END FORMING (STEEL AND ALUMINUM): EVALUATION OF EMISSION CONTROL OPTIONS

Option	Coating operation	Coating	kg VOC per litre of coating solids	Coating density (kg/litre)	Incineration requirements	VOC kg/1,000 ends (aluminum/steel)	% Reduction from base case (aluminum/steel)
Base case	End-sealing application	Solvent-based	1.01	0.948	None	0.071/0.108	-
Option VA	End-sealing application	Solvent-based	1.01	0.948	None	0.071/0.108	0/0
Option VB	End-sealing application	Water-based	0.05		None	0.0036/0.0053	95/95

TABLE 6-6. SUMMARY OF MODEL PLANT PARAMETERS, TWO-PIECE CAN SURFACE COATING[a]

(All Data Are per 1,000 Cans Unless Otherwise Indicated)

	Base case	Emission control option			
		IA	IB	IC	ID
VOC emissions					
kg	0.392	0.235	0.167	0.267	0.226
Mg/year, small scale[b]	157	94	67	107	90
Mg/year, large scale[c]	940	564	401	641	542
Ventilation air[d]					
scf, 100 ppmv	22,660	11,040	7,070	15,480	8,830
scf, 500 ppmv	4,530	2,210	1,415	3,095	1,765
acf, 100 ppmv	24,415	11,910	7,615	16,680	9,510
acf, 500 ppmv	4,885	2,380	1,525	3,335	1,900
Cure ovens[e]					
scf, small scale	8,565	8,565	5,710	8,565	5,710
scf, large scale	7,500	7,500	5,000	7,500	5,000
acf, small scale	14,980	14,970	9,980	14,970	9,980
acf, large scale	13,110	13,110	8,740	13,110	8,740
Btu, small scale	80,590	79,700	52,160	79,930	52,420
Btu, large scale	73,820	79,250	47,660	73,180	47,920
10^6 Btu/year, small scale	32,240	31,880	20,860	31,970	20,968
10^6 Btu/year, large scale	177,200	175,100	114,400	175,600	115,000
Incinerator[f]					
scf, small scale		10,560	7,275		
scf, large scale		9,495	6,565		
acf, small scale		17,140	11,670		
acf, large scale		15,270	10,430		
Btu, small scale		134,750	93,120		
Btu, large scale		124,100	82,460		
10^6 Btu/year, small scale		53,900	37,250		
10^6 Btu/year, large scale		297,800	197,900		

[a] Emission distribution used in developing model plant parameters.

For external base coat and overvarnish

Coater and flashoff	75
Cure oven	25

For inside spray

Coater and flashoff	80
Cure oven	20

[b] Small-scale plant--700 cans/min, 400 million cans/year.

[c] Large-scale plant 800 cans/min, 2,400 million cans/year.

[d] At 70° F. Aggregate of all coating operations.

[e] At 400° F. Separate cure oven for exterior base coat, lithography/overvarnish and inside spray. Data are aggregates of these coatings steps.

[f] Incinerator parameter: primary heat recovery--35 percent, afterburner temperature--1,400° F. One incinerator serves all coating operations. Secondary heat recovery limited to that attainable at 15 percent LEL.

TABLE 6-7. SUMMARY OF MODEL PLANT PARAMETERS, THREE-PIECE STEEL CAN SHEET COATING[a]

(All Data Are per 1,000 Cans Equivalent Unless Otherwise Indicated)

	Base case	Emission control option			
		IIA	IIB	IIC	IID
VOC emissions					
kg	0.234	0.073	0.064	0.215	0.180
Mg/year, small scale[b]	94	29	26	86	72
Mg/year, large scale[c]	187	58	51	172	144
Ventilation air[d]					
scf, 100 ppmv	1,790	490	395	1,600	1,340
scf, 500 ppmv	358	100	80	321	268
acf, 100 ppmv	1,930	530	435	1,725	1,445
acf, 500 ppmv	385	105	85	345	289
Cure ovens[e]					
scf, small scale	1,905	3,445	2,780	1,905	1,270
scf, large scale	1,560	3,445	2,780	1,560	1,040
acf, small scale	3,330	6,025	4,865	3,330	2,220
acf, large scale	2,730	6,025	4,865	2,725	1,820
Btu, small scale	32,590	39,880	29,750	31,120	20,990
Btu, large scale	30,400	39,880	29,750	28,920	19,430
10^6 Btu/year, small scale	13,040	15,950	11,900	12,450	8,395
10^6 Btu/year, large scale	24,320	31,900	23,800	23,140	15,540
Incinerator[f]					
scf, small scale		3,630	2,945		
scf, large scale		3,630	2,945		
acf, small scale		6,225	5,050		
acf, large scale		6,225	5,050		
Btu, small scale		27,230	26,870		
Btu, large scale		27,230	26,870		
10^6 Btu/year, small scale		10,890	10,750		
10^6 Btu/year, large scale		21,780	21,500		

[a] Emission distribution in developing model plant parameters. For all coating operations.

Coater-flashoff	10
Cure oven	90

[b] Small scale--90 sheets/min, 400 million cans/year.

[c] Large scale--110 sheets/min, 800 million cans/year.

[d] At 70° F. Aggregate of all coating operations.

[e] At 400° F. Separate cure oven for external base coat, internal base coat, and lithography/overvarnish. Data are aggregates of these coatings steps.

[f] Incinerator parameters: primary heat recovery--35 percent, afterburner temperature: 1,400° F. One incinerator serves all coating operations. Secondary heat recovery limited to that attainable at 15 percent LEL.

TABLE 6-8. SUMMARY OF MODEL PLANT PARAMETERS THREE-PIECE STEEL CAN INSIDE SPRAY[a]

(All Data Are per 1,000 Cans, Unless Otherwise Indicated)

	Base case	Emission control option	
		Option IIIA	Option IIIB
VOC emissions			
kg	0.207	0.086	0.107
Mg/year, small scale[b]	83	34.4	43
Mg/year, large scale[c]	166	68.8	86
Ventilation air[d]			
scf, 100 ppmv	12,350	2,990	6,380
scf, 500 ppmv	2,470	598	1,275
acf, 100 ppmv	13,300	3,220	6,875
acf, 500 ppmv	2,660	644	1,375
Cure ovens[e]			
scf, small scale	926	926	926
scf, large scale	1,850	1,850	1,850
acf, small scale	1,620	1,620	1,620
acf, large scale	3,235	3,235	3,235
Btu, small scale	12,710	12,290	12,540
Btu, large scale	18,580	18,146	18,410
10^6 Btu/year, small scale	5,085	4,910	5,016
10^6 Btu/year, large scale	14,860	14,510	14,730
Incinerator[f]			
scf, small scale		2,650	
scf, large scale		2,975	
acf, small scale		2,830	
acf, large scale		4,445	
Btu, small scale		20,646	
Btu, large scale		34,740	
10^6 Btu/year, small scale		8,255	
10^6 Btu/year, large scale		27,790	

[a] Emission distribution used in developing model plant parameters.

Coater and flashoff	80
Cure oven	20

[b] Small scale, 400 million cans/year.

[c] Large scale, 800 million cans/year.

[d] At 70° F. Includes coater and flashoff.

[e] At 400° F.

[f] Incinerator parameters: primary heat recovery--35 percent, afterburner temperature--1,400° F. Secondary heat recovery limited to that attainable at 15 percent LEL.

TABLE 6-9. SUMMARY OF MODEL PLANT PARAMETERS
STEEL- AND ALUMINUM-END SHEET COATING[a]
(All Data Are per 1,000 Ends, Unless Otherwise Indicated)

		Emission control option	
	Base case	Option IVA	Option IVB
VOC emissions			
kg	0.0305	0.0137	0.0145
Mg/year[b]	34	15	16
Ventilation air[c]			
scf, 100 ppmv	2,275	540	108
scf, 500 ppmv	455	110	22
acf, 100 ppmv	2,450	580	116
acf, 500 ppmv	490	116	23
Cure ovens[d]			
scf	336	336	336
acf	589	589	589
Btu	11,310	11,110	11,170
10^6 Btu/year	12,440	12,200	12,290
Incinerator[e]			
scf		336	
acf		589	
Btu		2,620	
10^6 Btu/year		2,880	

[a] Emission distribution used for all coating operations in developing model plant parameters.

Coater and flashoff	10
Cure oven	90

[b] Based on 1.1 billon ends per year.

[c] At 70° F. Includes coater and flashoff.

[d] At 400° F. Separate cure ovens for exterior and interior basecoater. Data are aggregate of exterior and interior base coat.

[e] Incinerator parameters: primary heat recovery--35 percent, afterburner temperature--1400° F. One incinerator serves both exterior and interior base coating. Secondary heat recovery limited to that attainable at 15 percent LEL.

TABLE 6-10. SUMMARY OF MODEL PLANT PARAMETERS, END FORMING (STEEL AND ALUMINUM), APPLICATION OF END-SEALING COMPOUND

(All Data Are per 1,000 Ends Under Otherwise Indicated)

	Base case	Emission control option VA	Emission control option VB
Aluminum ends			
VOC emissions			
kg	0.071	0.071	0.0036
Mg/yr[a]	78	78	4
Ventilation air[b]			
scf, 100 ppmv	5,290	5,290	268
scf, 500 ppmv	1,060	1,060	54
acf, 100 ppmv	5,700	5,700	289
acf, 500 ppmv	1,140	1,140	58
Steel ends			
VOC emissions			
kg	0.108	0.108	0.0053
Mg/yr[a]	189	189	6
Ventilation air[b]			
scf, 100 ppmv	8,050	8,050	395
scf, 500 ppmv	1,610	1,610	79
acf, 100 ppmv	8,675	8,675	426
acf, 500 ppmv	1,735	1,735	85

[a] Based on 1.1 billion ends per year.

[b] At 70° F.

	Small scale	Large scale
Number of can lines	2	6
Production rate, each line, cans per minute	700	800
Operating hours per year	4,700	8,400
Annual production, million cans	400	2,400

One United States can-line vendor has developed a modular 500-can-per-minute line that is preassembled on pallets, tested, and then shipped in 40 foot sections for installation and assembly. There are no plants of this type currently in operation in the United States. One plant is scheduled for installation for a national can manufacturer in 1980. No other U.S. orders are outstanding. However, negotiations are underway for one additional plant.[6] [7] The present and near-future status of this size of facility is not considered significant enough to warrant the inclusion of a 500-can-per-minute facility as a model plant at this time.

6.1.2 Three-Piece Beverage Cans

No record could be found of construction of three-piece beverage can plants within the past five years. The industry indicates an overcapacity because of the trend toward two-piece cans.[8] [9] [10] However, two sizes of plants are postulated for analyzing the economic impact of regulatory alternatives for the control of VOC emissions from three-piece beverage can plants that may be modified or reconstructed.

6.1.2.1 Small-Scale Three-Piece Can Plant. A small-scale three-piece beverage can plant produces beverage cans on a job-lot basis for customers requiring a modest number of cans for only a few product lines. Clientele is probably limited to regional soft drink plants and breweries.

Three-piece cans are in demand for soft drinks. The annual production of soft drink cans is currently about 25 billion units, with growth projected at approximately 7 percent.[11] Thus, there appears to be a need for 250-500 million incremental units of capacity every year. It is not unreasonable, then, to postulate a new facility with an annual capacity of 400 million units.

One base coater, operating 4,240 hours a year at 90 sheets per minute, is used to apply the exterior and interior base coats. One printing line satisfies the decoration and lithography requirements. The can-forming operation might consist of 12 body lines, each rated at three can bodies per second, serving one inside spray line and associated cure oven. The capacity factor for compatibility is 3,090 hours per year.

Steel and aluminum ends are assumed to be purchased from larger beverage can facilities and other suppliers.

6.1.2.2 Large-Scale Three-Piece Can Plant. The product of this plant is the same as that of the small-scale three-piece can plants, with perhaps a greater variety of decorating to suit a more diverse clientele. The hardware and methods are similar, with a capacity of 800 million cans per year achieved by twice as many lines as a small-scale plant. The principal difference in operating style is that this plant will make its own steel ends and, in fact, export some of them to smaller plants such as the one already described.

The justification for a three-piece plant of this scale, in view of the market description in Section 6.1.2, is tenuous. If such a plant were to be built, it would probably be in a densely populated region of the sunbelt such as southern California.

Two coating lines rated at 110 sheets/minute are postulated, with 35 can bodies per sheet at capacity factors of 3,460 hours/year. Because neither line need be dedicated to any particular coat, scheduling is more flexible and changeover down-time can be reduced.

There are also two printing lines. The assumed higher population density in the region permits larger filling plants and longer runs of particular designs. To be compatible with the coating machines requires a line speed of 90 sheets/minute and a capacity factor of 2,120 hours/year.

The can-forming operation might consist of 18 body lines, each rated at three can bodies per second, serving three ovens for curing the inside spray. The capacity factor for compatibility is 4,120 hours/year.

6.1.3 End-forming Plants

Steel ends are made from coated sheets, and aluminum ends from coated sheets or precoated coils. Precoated coils are not included in beverage can surface coating model plants. This activity is subject to proposed coil surface coating standards. Two model plants are applicable to beverage can ends, (1) steel or aluminum sheet coating and (2) steel- or aluminum-end forming.

6.1.3.1 Steel- or Aluminum-Sheet Coating. An exterior and an interior coat are applied to steel or aluminum sheets from which ends are formed. These coatings are applied on one machine dedicated to end stock coating running 90 sheets/minute, with a capacity factor of 1,540 hours/year for each coat.

6.1.3.2 Steel- or Aluminum-End Forming. End blanks are stamped out from coated sheets. Aluminum ends are also formed from precoated coils. A battery of sampling; shallow drawing; rolling machines; and, for ends used as tops for beverage cans, tab forming and processing machines are used. Rated speeds are from five to ten ends per second with an annual production rate of 1.1 billion ends per year. Following stamping of the ends, end-sealing compound is applied. The finished ends are packaged in paper sleeves, and stored at the end plant for a minimum of 48 hours for adequate air drying of the end-sealing compound.

6.2 BASE CASE

Although many plants in operation today use solvent-borne coatings, the trend is toward waterborne systems.[2 3 4 8 9 12 13] Waterborne coatings were used in developing emission limitations recommended in the CTG for can surface coating operations.[14] State Implementation Plans are currently undergoing revision to require emission limitations at least as stringent as those recommended in the CTG. Accordingly the use of waterborne coatings meeting emission limitations recommended in the CTG, for all can surface coating operations is properly considered the base case for the manufacture of two- and three-piece steel cans, two-piece aluminum cans, and steel ends. Solvent-based end-sealing compounds meeting the CTG emission limitations are the base case emissions for each of the model plants are shown in Tables 6-1 through 6-5, stated per thousand cans or ends.

6.3 REGULATORY ALTERNATIVES

This section presents a discussion of the regulatory alternatives to be considered for the beverage can industry. The impacts on emissions for each regulatory alternative are discussed in Chapter 7 of this document.

The following emission control options, described in detail in Chapter 4, were considered in developing regulatory alternatives for beverage can surface coating operations.

a. Incineration, thermal (solvent borne). VOC emissions from solvent-borne coatings, carried in vapor form in air, are heated with the carrier air to, for example, 1,400° F to burn or oxidize the VOC materials exothemically, essentially to carbon dioxide and water vapor. Primary heat recovery is provided, in which a portion of the heat is recovered by using the incinerator exhaust gases to preheat the incoming process gas stream. Control efficiency is nominally 90 percent of the emissions captured.

b. Incineration, catalytic (solvent borne). VOC emissions from solvent-borne coatings, carried in vapor form in air, are preheated with the carrier air to, for example, 600° F, then passed through a precious metal catalyst bed to burn or oxidize the VOC materials exothemically, essentially to carbon dioxide and water vapor. Primary heat recovery is provided, in which a portion of the heat is recovered by using the incinerator exhaust gases to preheat the incoming process gas stream. Control efficiency is nominally 90 percent of the emissions captured.

c. Low solvent--waterborne. This option entails the use of coating in which the volatiles portion consists of water and volatile organic compounds with about 80 percent being water.

d. UV cure. The solvent-borne overvarnish is replaced by a 100 percent solids UV curable overvarnish composition which contains monomers that cure or polymerize under the influence of ultraviolet radiation and moderate heat. Although no VOC is present in the system, up to 5 percent of the coating weight may be vaporized in the oven.

e. No-varnish inks. The solvent-borne overvarnish applied over lithographic inks is replaced by a system based on abrasion-resistant inks which eliminate the need for overvarnish to protect the printing and decoration.

f. Water-based end-sealing compounds. The solvent-based end-sealing compound meeting the emission limitation recommended in the CTG is replaced by a water-based compound formulated with no VOC.

The first regulatory alternative considered is no additional regulation. Under this alternative, emissions from beverage can plants would continue to be governed by State regulations. Existing beverage can plants located in ozone nonattainment areas will be subjected to SIP emission limitations generally based on the Control Technique Guideline document (CTG). New plants located in ozone nonattainment areas will be required to limit emissions to the lowest achiebable emission rate (LAER) and new plants in attainment areas to best available control technology (BACT). For beverage cans EPA has generally considered both LAER and BACT to be equivalent to the emission limitations recommended in the CTG. (The promulgation of an NSPS equivalent to the CTG limitations would have the same impact as no NSPS and is therefore not included as a separate regulatory alternative.)

The second regulatory alternative considered is one based on emission limitations resulting from the use of best available waterborne coatings for all coating operations. Similar reductions are attainable by the use of solvent-borne coatings and add-on controls. For end-sealing compounds, emission limitations based on the use of water-based materials with no VOC content are used in this regulatory alternative. Emission reduction resulting from this regulatory option, and incineration requirements if a facility elects to use solvent-borne coatings, are shown in Table 6-11. Other alternative emission control systems under the second regulatory alternative include eliminating the exterior base coat, eliminating the need for overvarnish through the use of no-varnish inks, or the use of UV-curable overvarnish coatings.

The third regulatory alternative is the same as the second except that no-varnish inks or UV-curable overvarnishes are used for lithography/overvarnish operations. Emission reductions resulting from this regulatory option, and incineration requirements if a facility elects to use solvent-borne coatings, are shown in Table 6-12. Elimination of a coating operation, e.g., exterior base coat, is also a viable alternative emission control system under the third regulatory alternative.

TABLE 6-11. INCINERATION REQUIREMENTS/SOLVENT-BORNE COATINGS FOR EQUIVALENCE WITH REGULATORY ALTERNATIVE II

	Waterborne coating upon which emission limitations are based			Reduction from base case (%)	Equivalent incineration requirements/solvent-borne coatings				
					Solvent-borne coating			Overall control requirement (%)	
	Vol. % solids	Wt. % VOC	Coating density kg/litre		Vol. % solids	Wt. % VOC	Coating density kg/litre	Cure oven	Coater/ flashoff
Two-piece aluminum and steel cans									
Emission control option	Option IC				Option IA				
Exterior base coat	42.6	9.5	1.283	51	45.0	[illegible]	1.142	90	69
Overvarnish	33.7	14.9	1.032	13	25.0	[illegible]	0.938	90	79
Inside spray	15.9	13.8	1.020	59	22.0	[illegible]	0.927	90	82
Three-piece steel can sheet coating									
Emission control option	Option IIC				Option IIA				
Exterior base coat	42.6	9.5	1.283	48	45.0	39.4	1.142	90	14
Interior base coat	29.0	12.1	1.054	13	22.0	71.5	1.015	90	76
Overvarnish	33.7	14.9	1.032	9	36.7	55.0	0.978	90	46
Three-piece steel can forming									
Emission control option	Option IIIB				Option IIIA				
Inside spray	15.9	13.8	1.020	28	22.0	21.0	1.000	90	69
Steel or aluminum end sheet coating									
Emission control option	Option IVB				Option IVA				
Exterior coat	33.7	14.9	1.032	7	45.0	46.4	1.008	61	0
Interior coat	29.0	12.1	1.050	40	22.0	71.5	1.015	90	77

TABLE 6-12. INCINERATION REQUIREMENTS/SOLVENT-BORNE COATINGS FOR EQUIVALENCE WITH REGULATORY ALTERNATIVE III

	Waterborne coating upon which emission limitations are based				Equivalent incineration requirements/solvent-borne coatings				
					Solvent-borne coating			Overall control requirement (%)	
	Vol. % solids	Wt. % VOC	Coating density kg/litre	Reduction from base case (%)	Vol. % solids	Wt. % VOC	Coating density kg/litre	Cure oven	Coater/ flashoff
Two-piece aluminum and steel cans									
Emission control option	Option ID				Option IB				
Exterior base coat	42.6	9.5	1.283	51	45.0	39.4	1.142	90	69
Overvarnish	No-varnish inks			91	No-varnish inks			0	0
Inside spray	15.9	13.8	1.020	59	22.0	71.5	0.927	90	82
Three-piece steel-sheet coating									
Emission control option	Option IID				Option IIC				
Exterior base coat	42.6	9.5	1.283	48	45.0	39.4	1.142	90	14
Interior base coat	29.0	12.1	1.054	13	22.0	71.5	1.015	90	76
Overvarnish	No-varnish inks or UV cure			89	No-varnish inks or UV cure			0	0
Three-piece steel-can forming									
Emission control option	Option IIIB				Option IIIA				
Inside spray	15.9	13.8	1.020	28	22.0	71.5	0.927	90	69
Steel or aluminum end sheet coating									
Emission control option	Option IVB				Option IVA				
Exterior coat	33.7	14.9	1.032	7	45.0	46.4	1.008	90	13
Interior coat	29.0	12.1	1.050	40	22.0	71.5	1.015	90	77

6.4 REFERENCES

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7. ENVIRONMENTAL IMPACT

7.1 AIR POLLUTION IMPACT

7.1.1 General

Metal can surface coating lines are major point sources of solvent emissions. The coatings contain volatile organic compounds (VOC) that are released into the air as the coatings dry. The metal can surface coating industry is one of several industries which apply solvent compound coatings that generate VOC emissions. In 1973, total United States consumption of solvent in paints and coatings was about 1,900,000 Mg (4,185 million pounds),[1] [2] of which 1,285,000 Mg (2,820 million pounds) were used directly in the manufacture of coating materials, and 620,000 Mg (1,365 million pounds) were used as thinner and for other miscellaneous purposes.[2] Solvent consumption in metal container coatings for 1979 is estimated at 134,000 Mg (295 million pounds), projecting from 1973 data and assuming a stable ratio of solvent usage to number of containers.

Solvent emissions from the beverage can industry occurs in the application, flashoff, and curing operations. The baseline emissions that are used to determine the incremental environmental impact of new source performance standards are emissions that would result with the emission limitation recommended in the control technique guideline document for metal can surface coating.[3] Emissions based on the CTG limitations are shown in Table 7-1.

The objective of new source performance standards is to limit pollutant emissions to the level achieved by the best system of continuous emission system, as determined by the Administrator. Several alternative VOC emission control option have been identified for beverage can surface coating operations.

The following sections discuss state regulations and the impact of each regulatory alternative on VOC emissions. Emissions under each alternative

TABLE 7-1. BASELINE EMISSIONS, BEVERAGE CAN SURFACE COATINGS[a]

Coating operation	kg VOC/1,000 units
Two-piece steel and aluminum cans	
Exterior base coat	0.137
Overvarnish	0.054
Inside spray	0.201
Total	0.392
Three-piece steel sheets	
Exterior base coat	0.137
Interior base coat	0.045
Overvarnish	0.045
Total	0.227
Three-piece steel can bodies	
Inside spray	0.189
Sheet coating, steel or aluminum ends	
Exterior base coat	0.0041
Interior base coat	0.0158
Total	0.0199
End forming (aluminum and steel)	
End-sealing application, aluminum	0.071
End-sealing application, steel	0.108

[a] Based on emission limitations recommended in the CTG.

emission control system that could serve as a basis for standards are compared to assess the environmental impact and degree of emission control achieved by each system. Other environmental impacts, such as potential water pollution and solid waste generation, are also assessed.

7.1.2 State Regulations and Controlled Emissions

In August 1971, Los Angeles County, California, adopted Rule 66, which controlled organic compound emissions. In 1976, Rule 66 was supplanted by South Coast Air Pollution Control District (SCAPCD)* Rule 442, which had similar provisions. Rule 442 states that emissions of photochemically reactive solvents† are not to exceed 18 kilograms (39.6 pounds) per day and emissions of nonphotochemically reactive solvents are limited to 1,350 kilograms (2,970 pounds) per day. Emissions from organic materials that come into contact with flame or are baked are limited to 6.5 kilograms (14.3 pounds) per day. Emissions above these limits are subject to 85 percent emission control. The regulation also provides exemptions for water-based coatings if the volatile content is 80 percent water.

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*Replaced by the South Coast Air Quality Management District (SCAQMD) on February 1, 1977.

†Photochemically reactive solvent means any solvent with an aggregate, or more than 20 percent of its total volume, composed of the chemical compounds classified below, or which exceeds any of the following individual percentage composition limitations, referring to the total volume of solvent:

a. A combination of hydrocarbons, alcohols, aldehydes, ethers, esters, or ketones having an olefinic or cycloolefinic type of unsaturation except perchloroethylene: 5 percent

b. A combination of aromatic compounds with eight or more carbon atoms to the molecule except ethylbenzene, methylbenzoate, and phenyl acetate: 8 percent

c. A combination of ethylbenzene, ketones with branched hydrocarbon structures, trichloroethylene or toluene: 20 percent

Whenever any organic solvent or any constitutent of an organic solvent may be classified from its chemical structure into more than one of the above groups of organic compounds, it shall be considered a member of the most reactive chemical groups, that is, that group having the least allowable percent of the total volume of solvents.

A review of state VOC regulations published in The Environmental Reporter (July 1979) shows a wide range of control requirements. A summary of the state VOC regulations is presented in Table 7-2. Six states have rules specific to surface coating operations; 21 states (including the District of Columbia and Puerto Rico) specify numerical emission limits for VOC in mass per unit of time; nine states have broadly worded general rules requiring that "reasonable care" be exercised to reduce organic emissions. Almost half the states have no rules or regulations except for the storage, loading, and transfer of volatile organic compounds where large tanks and a high throughput are involved, e.g., petroleum distribution systems.

The regulations of 15 of the states specifying numerical emission limits appear to have been modeled after Regulation IV of the California South Coast Air Quality Management District. Typically, emission limits are given for equipment where any organic materials are exposed to high temperatures and where photochemically reactive materials are used or applied. These provisions clearly cover drying ovens and coating facilities, although they are not named directly. In addition, some state regulations include provisions controlling the use of nonphotochemically reactive solvents, drying of articles after removal from equipment, cleanup operations, acceptable methods of control (incineration, adsorption, etc.), and disposal of waste solvents. Exemptions are usually granted where waterborne, high-solid, or low-organic coating materials are used.

There are many variations and interpretations of requirements among states that have Rule 442-type regulations. There has been considerable debate at both the State and Federal levels over what constitutes a photochemically reactive solvent and a nonphotochemically reactive solvent. The situation is further complicated because the States are currently revising their regulations.

The Clean Air Act Amendment of 1977 requires all states to submit revised State Implementation Plans (SIP) to EPA for approval by January 1, 1979. Revised SIPs must include strategies demonstrating attainment of ambient air quality standards for carbon monoxide and photochemical oxidants by December 31, 1982. An extension to December 31, 1987, may be granted if it is demonstrated that attainment is not possible by 1982 despite implementation of reasonably available control technology.

TABLE 7-2. PROFILE OF ORGANIC EMISSIONS REGULATIONS BY STATES[4]

Organic solvents			
No specific rule	"Reasonable care"	Numerical emissions limits	Special can or surface coating rules
Alaska	Arizona	Alabama	California (SCAQMD)
Delaware	Arkansas	California (SCAQMD)	Illinois
Georgia	Florida	Colorado	Kentucky
Hawaii	Kansas	Connecticut	Michigan
Idaho	Mississippi	District of Columbia	Texas
Iowa	Nevada	Illinois	Wisconsin
Maine	New Hampshire	Indiana	
Massachusetts	North Dakota	Kentucky	
Minnesota	Wyoming	Louisiana	
Missouri		Maryland	
Montana		Maryland	
Nebraska		New York	
New Jersey		North Carolina	
New Mexico		Ohio	
Oregon		Oklahoma	
South Carolina		Pennsylvania (Philadelphia)	
South Dakota		Puerto Rico	
Utah		Rhode Island	
Vermont		Tennessee	
Washington		Texas	
West Virginia		Virginia	
		Wisconsin	

Attainment of the ozone standard in areas designated as nonattainment is to be accomplished by a variety of measures, including the application of reasonably available control technology to VOC sources for which control technique guideline documents have been published. Such a document has been published for metal can surface coating operations. Revised SIPs are currently under review by EPA. In addition, several states have indicated that VOC emission limitations based on those recommended in the CTG would also be required in about 515 counties in their jurisdiction that have not been designated as nonattainment areas.[5] This brings the number of counties subject to CTG emission limitations to over 900. It is estimated that imposing CTG limitations on metal can surface coating plants located in these 900 counties would reduce VOC emissions by as much as 113,000 Mg.[5] Emission limitations recommended in the CTG for can surface coating are shown in Table 7-3.

7.1.3 Comparative Emissions from Model Plants Employing Various Emission Control Options

The various options that have been considered in this document (see chapter 4) and selected as emission control options are summarized in Table 7-4. Comparative emissions of model plants using these options are discussed below for each of the beverage can model plants developed in Chapter 6.

Annual emissions for each of the model plants are determined by applying the emission factors, expressed as kilograms of VOC per 1,000 cans, developed in Chapter 6.

7.1.3.1 Two-Piece Aluminum and Steel Integrated Facility. Two model plants are assumed for two-piece can manufacturing: a small-scale plant, with two lines producing 400 million cans per year, and a large-scale plant, with six lines producing 2,400 million cans per year. Annual emissions for each of these plants for the base case and for emission control options listed in Table 7-4 are shown in Table 7-5.

7.1.3.2 Three-Piece Can Sheet Coating. Two model plants are assumed for new sheet coating lines: A small-scale plant coating sheets equivalent to 400 million cans per year, and a large-scale plant coating sheets equivalent to 800 million cans per year. Annual emissions for each of these plants for the base case and for emission control options listed in Table 7-4 are shown in Table 7-6.

TABLE 7-3. RECOMMENDED CTG EMISSION LIMITATIONS FOR CAN SURFACE COATINGS[3]

Affected facility	Recommended limitation kg per litre of coating (minus water)	lb per gal of coating (minus water)
Sheet base coat (exterior and interior) and overvarnish; two-piece can exterior (base coat and overvarnish)	0.34	2.8
Two and three-piece can interior body spray, two-piece can exterior end (spray or roll coat)	0.51	4.2
Three-piece can side-seam spray	0.66	5.5
End sealing compound	0.44	3.7

TABLE 7-4. EMISSION CONTROL OPTIONS[a]

I	Two-piece aluminum or steel integrated facility	
	Operations	Exterior base coat, lithography/overvarnish, inside spray
	Base case	CTG waterborne coatings for all operations
	Option IA	Solvent-borne coating. Capture and incineration of coater and cure oven emissions from all operations and flashoff emissions from inside spray
	Option IB	Same as IA except no-varnish or UV-cure inks for lithography/overvarnish
	Option IC	Low-solvent coatings for all operations
	Option ID	Same as IC except no varnish or UV-cure inks for lithography/overvarnish
II	Three-piece can sheet coatings	
	Operations	Exterior base coat, interior base coat, lithography/overvarnish
	Base case	CTG waterborne coatings for all operations
	Option IIA	Solvent-borne coatings for all operations. Capture and incineration of coater, flashoff, and cure oven emissions
	Option IIB	Same as IIA except no-varnish or UV-cure coatings for lithography/overvarnish
	Option IIC	Low-solvent coatings for all operations
	Option IID	Same as IIC except no-varnish or UV-cure coatings for lithography/overvarnish
III	Three-piece can forming	
	Operation	Inside spray
	Base case	CTG waterborne coating
	Option IIIA	Solvent-borne coating. Capture and incineration of coater, flashoff, and cure oven emissions
	Option IIIB	Low-solvent coating
IV	Sheet coating, steel or aluminum ends	
	Operations	Exterior base coat, interior base coat
	Base case	CTG waterborne coatings for all operations
	Option IVA	Solvent-borne coatings for all operations. Capture and incineration of coater, flashoff, and cure oven emissions
	Option IVB	Low-solvent coating
V	End forming (aluminum and steel)	
	Operation	End-sealing compound application
	Base case	CTG solvent-based compound
	Option VA	CTG solvent-based compound
	Option VB	Water-based compound

[a] These options are identified and described in Chapter 6.

TABLE 7-5. EMISSIONS FROM BASE CASE AND EMISSION CONTROL OPTIONS, TWO-PIECE ALUMINUM- AND STEEL-INTEGRATED FACILITY (Mg/year)

	Small scale (400 million cans/yr)				Large scale (2,400 million cans/yr)			
	Exterior base coat	Lithography/ overvarnish	Inside spray	Total	Exterior base coat	Lithography/ overvarnish	Inside spray	Total
Base case	55	22	80	157	329	130	481	940
Option IA	30	29	35	94	182	175	207	564
Option IB	30	2	35	67	122	12	207	401
Option IC	29	19	59	107	175	111	355	641
Option ID	29	2	59	90	175	12	355	542

TABLE 7-6. EMISSIONS FROM BASE CASE AND EMISSION CONTROL OPTIONS, THREE-PIECE CAN SHEET COATING (Mg/year)

	Small scale (400 million cans/year)				Large scale (800 million cans/year)			
	Exterior base coat	Interior base coat	Lithography/ overvarnish	Total	Exterior base coat	Interior base coat	Lithography/ overvarnish	Total
Base case	58	18	18	91	115	36	36	187
Option IIA	12	11	6	29	24	23	11	58
Option IIB	12	12	2	26	24	23	4	51
Option IIC	52	18	16	86	105	35	32	172
Option IID	52	18	2	72	105	35	4	144

7.1.3.3 Three-Piece Steel-Can Forming. Two model plants, a small-scale plant forming 400 million cans per year and a large-scale plant forming 800 million cans per year, are assumed. Annual emissions for each of these plants for the base case and for emission control options listed in Table 7-4 are shown in Table 7-7.

7.1.3.4 Sheet Coating, Steel or Aluminum Ends. One size model plant with a capacity of coating sheets to make 1.1 billion ends per year is assumed. Annual emissions for the base case and for each emission control option listed in Table 7-4 are shown in Table 7-8.

7.1.3.5 End Forming, Aluminum or Steel. One size model plant with a capacity of forming 1.1 billion ends per year is assumed for the manufacture of aluminum ends from precoated aluminum strip or the manufacture of steel ends from precoated steel sheets. Annual emissions for the base case and for each emission control option listed in Table 7-4 are shown in Table 7-9.

7.1.4 Estimated VOC Emission Reduction in Future Years

7.1.4.1 General. Growth in total beverage can manufacturing from 1978 to 1983 is estimated at about 5.5 percent per year, based on forecasts published in Metal Bulletin[6] and Modern Packaging.[7] Growth in two-piece aluminum beverage cans is estimated at about 7 percent per year. Annual production of three-piece steel beverage cans is expected to remain essentially unchanged from 1978 to 1983, while production of two-piece steel beverage cans is projected to increase by 10 percent per year. These estimates are the basis of the projections shown in Table 7-10. There are other industry projections that would change the estimates of 1985 capacity subject to the NSPS. For example, some industry sources project the demise of the three-piece can over the next 5 years.[8] [9] Others indicate that while the use of three-piece beverage cans will drop, they will still represent a significant share of the market.[6] [7]

Plants for which construction, modification or reconstruction began after the proposal date will be subject to the NSPS. The capacity subject to NSPS is estimated shown in Table 7-11. These projections assume that 5 percent of the 1980 capacity will be subject to NSPS, because of modification or reconstruction.

Incremental environmental impact, expressed as changes in VOC emissions, is the difference between emissions under limitations recommended in the

TABLE 7-7. EMISSIONS FROM BASE CASE AND EMISSION CONTROL OPTIONS, THREE-PIECE CAN FORMING (INSIDE SPRAY) (Mg/year)

	Small scale (400 million cans/yr)	Large scale (800 million cans/yr)
Base case	83	166
Option IIIA	34	69
Option IIIB	43	86

TABLE 7-8. EMISSIONS FROM BASE CASE AND EMISSION CONTROL OPTIONS, SHEET COATING, STEEL AND ALUMINUM ENDS (Mg/year)

	Exterior base coat	Interior base coat	Total
Base case	5	29	34
Option IVA	2	13	15
Option IVB	4	12	16

TABLE 7-9. EMISSIONS FROM BASE CASE AND EMISSION CONTROL OPTIONS, END FORMING (STEEL AND ALUMINUM), END-SEALING COMPOUND APPLICATION
(Mg/year)

	Aluminum	Steel
Base case	78	189
Option VA	78	189
Option VB	4	6

TABLE 7-10. ANNUAL PRODUCTION OF BEVERAGE CANS, 1978-1985 (billion cans)[a]

Type of can	1978	1979	1980	1981	1982	1983	1984	1985
Two-piece steel	9.8	10.8	11.9	13.0	14.3	15.8	17.4	19.1
Two-piece aluminum	30.1	32.1	34.1	36.4	38.7	41.2	43.9	46.8
Three-piece steel	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
Total	54.4	57.4	60.5	63.9	67.5	71.5	75.8	80.4

[a] Data for 1978 are based on actual production. All other years are estimates.

TABLE 7-11. ESTIMATED BEVERAGE CAN PRODUCTION SUBJECT TO NSPS, 1980-1985 (billion cans or ends)

	1980	1981	1982	1983	1984	1985
Two-piece steel and aluminum cans						
1980 production	46.0	49.4	53.0	57.0	61.3	65.9
Growth	0	3.4	3.6	4.0	4.3	4.6
Modification/reconstruction	0	2.3	2.3	2.3	2.3	2.3
Subject to NSPS	0	5.7	5.9	6.3	6.6	6.9
Cumulative	0	5.7	11.6	17.9	24.5	31.4
Three-piece sheet coating and can forming						
1980 production	14.5	14.5	14.5	14.5	14.5	14.5
Growth	0	0	0	0	0	0
Modification/reconstruction	0	0.7	0.7	0.7	0.7	0.7
Subject to NSPS	0	0.7	0.7	0.7	0.7	0.7
Cumulative	0	0.7	1.4	2.1	2.8	3.5
Steel ends for three-piece steel cans[a]						
1980 production	14.5	14.5	14.5	14.5	14.5	14.5
Growth	0	0	0	0	0	0
Modification/reconstruction	0	0.7	0.7	0.7	0.7	0.7
Subject to NSPS	0	0.7	0.7	0.7	0.7	0.7
Cumulative	0	0.7	1.4	2.1	2.8	3.5
Aluminum ends for two-piece and three-piece steel cans[b]						
1980 production	60.5	63.9	67.5	71.5	75.8	80.4
Growth	0	3.4	3.6	4.0	4.3	4.6
Modification/reconstruction	0	3.0	3.0	3.0	3.0	3.0
Subject to NSPS[c]	0	3.2	3.3	3.5	3.6	3.8
Cumulative	0	3.2	6.5	10.0	13.6	17.4

[a] One per three-piece steel can.

[b] One per can, two-piece or three-piece.

[c] Assumes one half of growth and modification or reconstruction occurs in plants using sheet stock to manufacture ends.

CTG and emissions under the emission control options. Using the emission factors developed in Chapter 6 for the base case and the various emission control options, emission reductions from NSPS through 1985 can be estimated. These estimates are shown in Table 7-12 for aluminum and steel two-piece can facilities, Table 7-13 for three-piece can sheet coating, Table 7-14 for three-piece can forming, Table 7-15 for sheet coating for steel or aluminum ends, and Table 7-16 for aluminum or steel end forming.

No emission reductions would result under Regulatory Alternative I. Regulatory Alternative II would reduce emissions in 1985 by 9,782 Mg per year, Regulatory Alternative III by 11,205 Mg per year. Reductions from individual beverage can surface coating operations presented in Table 7-12 through 7-16 are summarized in Table 7-17.

7.2 WATER POLLUTION IMPACT

Because there are no process water streams in can coating operations, the problem of water pollution from coating operation discharges to plant effluent wastewater streams normally does not exist. However, there are opportunities for intermittent discharge of pollutants to plant effluent wastewater streams when low-solvent waterborne coatings are used. This problem is essentially the same under all control options using waterborne coatings.

The use of low-solvent waterborne coatings could result in water pollution during cleaning of coating equipment at the ends of coating runs. Where solvent-borne coatings are used, the solvents are normally not miscible with water, and equipment is cleaned with organic cleaning solvents also not miscible with water. Residual solvent-borne coating material in the reservoir of the coating machine is recovered and collected at the end of a coating run, together with the cleaning solvent for reuse in future coating runs. Small quantities of cleaning solvent contaminated with dirt, foreign matter, and coating material may not be reusable, but because the solvents are not miscible with water, the waste is not discharged into plant effluent wastewater streams.

However, where waterborne coatings are used, water with soap or detergent is used for equipment cleanup. While residual waterborne coating material on the coating machine at the end of a run is recovered and collected for reuse, cleaning water contaminated with dirt, foreign matter,

TABLE 7-12. EMISSION REDUCTIONS FROM EMISSION CONTROL OPTIONS, TWO-PIECE STEEL AND ALUMINUM INTEGRATED FACILITY, 1985[a]

Coating operation	Base case		Option IA		Option IB		Option IC		Option ID	
	kg/10^3 units	Mg	kg/10^3 units	Mg	kg/10^3 units	Mg	kg/10^3 units	Mg	kg/10^3 units	Mg
Exterior base-coat operation	0.137	4,302	0.076	2,386	0.076	2,386	0.073	2,292	0.073	2,292
Lithography/overvarnish	0.054	1,695	0.073	2,292	0.005	157	0.046	1,444	0.005	157
Inside spray[b]	0.223	7,002	0.097	3,046	0.097	3,046	0.164	5,150	0.164	5,150
Total	0.413	12,999	0.246	7,724	0.178	5,589	0.283	8,886	0.242	7,599
Reduction from NSPS		--		5,275		7,376		4,113		5,400

[a] Affected capacity is based on 31.4 billion can equivalents subject to NSPS in 1985.

[b] Based on a 90 percent transfer efficiency.

TABLE 7-13. EMISSION REDUCTIONS FROM EMISSION CONTROL OPTIONS, THREE-PIECE CAN SHEET COATING, 1985[a]

	Base case		Option IIA		Option IIB		Option IIC		Option IID	
Coating operation	kg/10^3 units	Mg	kg/10^3 units	Mg	kg/10^3 units	Mg	kg/10^3 units	Mg	kg/10^3 units	Mg
Exterior base coat	0.142	398	0.030	84	0.030	84	0.131	367	0.131	367
Interior base coat	0.046	129	0.029	81	0.029	81	0.044	123	0.044	123
Lithography/overvarnish	0.046	129	0.014	39	0.005	14	0.040	112	0.005	14
Total	0.234	656	0.073	204	0.064	179	0.215	602	0.180	504
Reduction from NSPS		---		452		477		54		152

[a] Affected capacity is based on 2.8 billion can equivalents subject to NSPS in 1985.

TABLE 7-14. EMISSION REDUCTIONS FROM EMISSION CONTROL OPTIONS, THREE-PIECE CAN FORMING, 1985[a]

	Base case		Option IIIA		Option IIIB	
Coating operation	kg/10^3 units	Mg	kg/10^3 units	Mg	kg/10^3 units	Mg
Inside spray[b]	0.230	644	0.097	272	0.119	333
Reduction from NSPS		--		372		311

[a] Affected capacity is based on 2.8 billion can equivalents subject to NSPS in 1985.

[b] Based on 90 percent transfer efficiency.

TABLE 7-15. EMISSION REDUCTIONS FROM EMISSION CONTROL OPTIONS, SHEET COATING, STEEL AND ALUMINUM ENDS, 1985[a]

Coating operation	Base case		Option IVA		Option IVB	
	kg/10^3 units	Mg	kg/10^3 units	Mg	kg/10^3 units	Mg
Exterior base coat	0.0042	86	0.0016	33	0.0040	84
Interior base coat	0.0263	550	0.0122	255	0.0105	219
Total	0.0305	636	0.0138	288	0.0145	303
Reduction from NSPS		---		348		333

[a] Affected capacity is based on 3.5 billion steel ends and 17.4 billion aluminum end equivalents subject to NSPS in 1985.

TABLE 7-16. EMISSION REDUCTION FROM EMISSION CONTROL OPTIONS, END FORMING, STEEL AND ALUMINUM, 1985[a]

Coating operation	Base case kg/10^3 units	Base case Mg	Option VA kg/10^3 units	Option VA Mg	Option VB kg/10^3 units	Option VB Mg
Aluminum ends	0.071	2,478	0.071	2,478	0.0036	126
Steel ends	0.108	378	0.108	378	0.0053	19
Total		2,856		2,856		145
Reduction from NSPS				0		2,711

[a] Affected capacity is based on 34.9 billion aluminum ends and 3.5 billion steel ends subject to NSPS in 1985.

TABLE 7-17. BEVERAGE CAN SURFACE COATING: EMISSION REDUCTION FROM REGULATORY ALTERNATIVES, Mg PER YEAR, 1985

Emission source	Regulatory alternative		
	I	II	III
Two-piece steel and aluminum can integrated facilities	0	4,113	5,400
Three-piece can sheet coating	0	54	152
Three-piece can forming	0	311	311
Steel or aluminum end sheet coating	0	333	333
Steel or aluminum end forming	0	2,711	2,711
Total	0	7,522	8,907

soap, and small amounts of coating material, including solvent, could be discharged into plant effluent wastewater streams.

The level of water pollution from coating cleanup operations is very low. The problem with some organic solvents in effluent water is more a matter of chemical oxygen demand (COD) than toxicity. A COD load is not a pollutant in itself; it becomes a problem only if it is discharged to a stream in sufficient concentration and quantity to deplete the oxygen in the stream and affect fish and other water life.

The various can coating emission control options do not require any changes in can washing or other operations performed prior to coating, and therefore have no effect on noncoating water pollution aspects of can manufacture.

7.3 SOLID WASTE DISPOSAL IMPACT

There is essentially no potential solid waste impact associated with any of the can coating regulatory control options.

Small quantities of solid waste, either a slurry of coating material in cleaning solvent or lumps or films of coating material, are generated during equipment cleanup at the end of a coating run. For the no-varnish inks control option, this source of solid waste is nonexistent, because no overvarnish coating is applied. For waterborne coating control options, cleanup waste is a water rather than a solid waste disposal matter. For all other control options, cleanup waste is the same as for base cases.

Another potential source of solid waste is project rejects from the coating operations. In general, all reject cans and scrap metal are recycled. The product reject and recycle rate for control option coating processes is expected to be no different from the base cases, so that there will be no control option impact on this solid waste source.

7.4 ENERGY IMPACT

The application of can coatings considered in this document use energy in the form of electricity, natural gas, and in some instances other fossil fuels. Electricity is used to drive coating equipment, sheet and can conveyors, ventilating blowers at the coater and flashoff areas, oven circulating and exhaust blowers, incineration system blowers, and UV lamps for UV-curing coating systems. Natural gas is used as fuel for the drying and curing ovens and may be used as fuel for incinerators.

The energy impacts associated with each emission control option are summarized in Tables 7-18 through 7-21. These tables compare the primary energy required for the base case beverage can surface coating module with the primary energy required when pollution reduction coatings and/or add-on emission controls are used. The data in Tables 7-18 through 7-21 represent only energy requirements affected by the emission control options, not the total requirements. Energy requirements for coater and conveyor drivers, can forming equipment, and similar steps are not included. However electrical energy requirements for ventilating air, cure oven air, incinerator air; and natural gas requirements for cure ovens and incinerators, are included.

Data in Tables 7-18 through 7-21 are presented on the basis of 1,000 cans or ends. Combining these data with the estimated beverage can production subject to NSPS in 1985 (see Table 7-10) results in the estimated changes in energy requirements compared to the base case as shown in Tables 7-22 through 7-25. Analysis of the data in Tables 7-18 through 7-21 indicates that there is only an insignificant difference in energy requirements between 100 and 500 ppmv VOC as xylene in ventilating air. Therefore only data for 100 ppmv are presented in Tables 7-22 through 7-25.

Energy requirements for the base case and control options for aluminum or steel end forming are essentially the same. There would be no reduction in energy requirements for beverage can surface coating under Regulatory Alternative I. Regulatory Alternative II would result in a net energy reduction of 59,790 gigajoules per year in 1985; Regulatory Alternative III in a reduction of 889,339 gigajoules. Net energy reductions from individual beverage can surface coating operations presented in Tables 7-22 through 7-25 are summarized in Table 7-26.

7.5 OTHER ENVIRONMENTAL IMPACTS

Other environmental areas which are affected by can coating emission control options are space and use of petroleum-derived materials.

Compared to base cases, no-varnish inks control options in lieu of overvarnish eliminate a coating step and reduce plant space requirements. Low solvent waterborne and UV-curing coating control options have no plant space impact. Incineration control options require plant space for the add-on control equipment and associated duct work.

TABLE 7-18. ENERGY IMPACT OF EMISSION CONTROL OPTIONS[a]
TWO-PIECE CANS
(10^6 joules per 1,000 cans)

	Base case		Emission control option							
			Option IA		Option IB		Option IC		Option ID	
	Small scale	Large scale	Small scale	Large scale	Small scale	Large scale	Small scale	Large scale	Small scale	Large scale
Electrical energy										
Ventilating air, 100 ppmv, VOC	0.574	0.574	0.426	0.426	0.325	0.325	0.392	0.392	0.223	0.223
Ventilating air, 500 ppmv, VOC	0.115	0.115	0.085	0.085	0.065	0.065	0.078	0.078	0.044	0.044
Cure oven/incinerator air	1.760	1.540	2.014	1.794	1.371	1.226	1.761	1.542	1.174	1.028
Subtotal (100 ppmv)	2.334	2.114	2.440	2.220	1.696	1.551	2.153	1.934	1.397	1.251
Subtotal (500 ppmv)	1.875	1.655	2.099	1.879	1.436	1.291	1.839	1.620	1.218	1.072
Natural gas										
Cure oven	84.958	77.821	84.020	76.904	54.987	50.243	84.262	77.146	55.261	50.517
Incinerator	0	0	142.053	130.826	98.167	86.929	0	0	0	0
Subtotal	84.958	77.821	226.073	207.730	153.154	137.172	84.262	77.146	55.261	50.517
Total energy demand										
With ventilating air at 100 ppmv	87.292	79.935	228.513	209.950	154.850	138.723	86.415	79.080	56.658	51.768
With ventilating air at 500 ppmv	86.633	79.476	228.172	209.609	154.590	138.463	86.101	78.766	56.479	51.589

[a] Totals do not include energy requirements that are the same for all options; e.g., electricity to drive coating equipment, sheet and can conveyors, etc.

TABLE 7-19. ENERGY IMPACT OF EMISSION CONTROL OPTIONS[a] THREE-PIECE CAN SHEET COATING (10^6 joules per 1,000 cans)

	Base case		Emission control option							
			Option IIIA		Option IIIB		Option IIIC		Option IIID	
	Small scale	Large scale	Small scale	Large scale	Small scale	Large scale	Small scale	Large scale	Small scale	Large scale
Electrical energy										
Ventilating air, 100 ppmv, VOC	0.045	0.045	0.013	0.013	0.010	0.010	0.041	0.041	0.034	0.034
Ventilating air, 500 ppmv, VOC	0.009	0.009	0.003	0.003	0.002	0.002	0.008	0.008	0.007	0.007
Cure oven/incinerator air	0.391	0.321	0.731	0.731	0.593	0.593	0.391	0.321	0.261	0.214
Subtotal (100 ppmv)	0.436	0.366	0.744	0.744	0.603	0.603	0.432	0.362	0.292	0.248
Subtotal (500 ppmv)	0.400	0.330	0.734	0.734	0.595	0.595	0.399	0.329	0.268	0.221
Natural gas										
Cure oven	34.356	32.048	42.041	42.041	31.362	31.362	32.765	30.445	21.991	20.441
Incinerator	0	0	28.706	28.706	28.326	28.326	0	0	0	0
Subtotal	34.356	32.048	70.747	70.747	59.688	59.688	32.765	30.445	21.991	20.441
Total energy demand										
With ventilating air at 100 ppmv	34.792	32.414	71.491	71.491	60.291	60.291	33.197	30.807	22.283	20.689
With ventilating air at 500 ppmv	34.756	32.378	71.481	71.481	60.283	60.283	33.162	30.774	22.259	20.662

[a] Totals do not include energy requirements that are the same for all options; e.g., electricity to drive coating equipment, sheet and can conveyors, etc.

TABLE 7-20. ENERGY IMPACT OF EMISSION CONTROL OPTIONS[a]
THREE-PIECE STEEL CAN, INSIDE SPRAY
(10^6 joules per 1,000 cans)

	Emission control option					
	Base case		Option IIIA		Option IIIB	
	Small scale	Large scale	Small scale	Large scale	Small scale	Large scale
Electrical energy						
Ventilating air, 100 ppmv, VOC	0.356	0.356	0.086	0.086	0.164	0.164
Ventilating air, 500 ppmv, VOC	0.071	0.071	0.017	0.017	0.033	0.033
Cure oven/incincerator air	0.109	0.217	0.333	0.522	0.109	0.217
Subtotal (100 ppmv)	0.465	0.573	0.419	0.608	0.273	0.381
Subtotal (500 ppmv)	0.180	0.288	0.350	0.539	0.142	0.250
Natural gas						
Cure oven	13.399	19.587	12.946	19.123	13.220	19.408
Incinerator	0	0	21.759	36.623	0	0
Subtotal	13.399	19.587	34.705	55.746	13.220	19.408
Total energy demand						
With ventilating air at 100 ppmv	13.864	20.160	35.124	56.354	13.493	19.789
With ventilating air at 500 ppmv	13.579	19.875	35.055	56.285	13.362	19.658

[a] Totals do not include energy requirements that are the same for all options, e.g., electricity to drive coating equipment, sheet and can conveyors, etc.

TABLE 7-21. ENERGY IMPACT OF EMISSION CONTROL OPTIONS[a] STEEL OR ALUMINUM END SHEET COATING (10^6 joules per 1,000 ends)

	Base case	Emission control option	
		Option IVA	Option IVB
Electrical energy			
Ventilating air, 100 ppmv, VOC	0.058	0.014	0.003
Ventilating air, 500 ppmv, VOC	0.012	0.003	0.001
Cure oven/incinerator air	0.069	0.069	0.069
Subtotal (100 ppmv)	0.127	0.083	0.072
Subtotal (500 ppmv)	0.081	0.072	0.070
Natural gas			
Cure oven	11.923	11.712	11.775
Incinerator	0	2.762	0
Subtotal	11.923	14.474	11.775
Total energy demand			
With ventilating air at 100 ppmv	12.050	14.557	11.847
With ventilating air at 500 ppmv	12.004	14.546	11.845

[a] Totals to not include energy requirements that are the same for all options; e.g., electricity to drive coating equipment, sheet and can conveyors, etc.

TABLE 7-22. ENERGY REQUIREMENT FOR EMISSION CONTROL OPTIONS, TWO-PIECE CANS, SUBJECT TO NSPS IN 1985[a,b,c] (gigajoules)

	Small scale					Large scale				
	Base case	Emission control option				Base case	Emission control option			
		IA	IB	IC	ID		IA	IB	IC	ID
Electricity	73,288	76,616	53,254	67,604	43,866	66,380	69,708	48,701	60,728	39,281
Natural gas	2,667,681	7,098,692	4,809,036	2,645,827	1,735,195	2,443,579	6,522,722	4,307,201	2,442,384	1,586,234
Total	2,740,969	7,175,308	4,862,290	2,713,431	1,779,061	2,509,959	6,592,430	4,355,902	2,483,112	1,625,515
Reduction due to NSPS		(4,434,339)	(2,121,321)	27,538	961,908		(4,082,471)	(1,845,943)	26,847	884,444

[a] VOC concentration in ventilating air is ppmv 100 as xylene. Affected capacity is based on 31.4 billion cans subject to NSPS in 1985.

[b] Figures in parentheses indicate an increase in energy requirements over the base case.

[c] Assumes 25 percent of two-piece cans are steel, the same ratio as in 1978.

TABLE 7-23. ENERGY REQUIREMENT FOR EMISSION CONTROL OPTIONS,[a] THREE-PIECE CAN SHEET COATING, SUBJECT TO NSPS BY 1985[b]
(gigajoules)

	Small scale					Large scale				
	Base case	Emission control option				Base case	Emission control option			
		IIA	IIB	IIC	IID		IIA	IIB	IIC	IID
Electricity	1,221	2,083	1,688	1,210	818	1,025	2,083	1,688	1,014	694
Natural gas	96,197	198,092	167,126	91,742	61,575	89,734	198,092	167,126	85,246	57,235
Total	97,418	200,175	168,814	92,952	62,392	90,759	200,175	168,814	86,260	57,929
Reduction due to NSPS		(102,757)	(71,396)	4,466	35,026		(109,416)	(78,055)	4,499	32,830

[a] VOC concentration in ventilating air is 100 ppmv as xylene. Affected capacity is based on 2.8 billion can equivalents subject to NSPS in 1985.

[b] Figures in parentheses indicate an increase in energy requirements over the base case.

TABLE 7-24. ENERGY REQUIREMENT FOR EMISSION CONTROL OPTIONS, THREE-PIECE CAN INSIDE SPRAY, SUBJECT TO NSPS IN 1985[a,b]
(gigajoules)

	Small scale			Large scale		
		Emission control option			Emission control option	
	Base case	IIIA	IIIB	Base case	IIIA	IIIB
Electricity	1,302	1,173	764	1,604	1,702	1,067
Natural gas	37,517	97,174	37,016	54,844	156,089	54,342
Total	38,819	98,347	37,780	56,448	157,791	55,409
Reduction due to NSPS[c]		(59,523)	39		(101,343)	1,039

[a] VOC concentration in ventilating air is 100 ppmv as xylene. Affected capacity is based on 2.8 billion cans subject to NSPS in 1985.

[b] Figures in parentheses indicate an increase in energy requirements over the base case.

[c] Based on 15 percent LEL.

TABLE 7-25. ENERGY REQUIREMENT FOR EMISSION CONTROL OPTIONS, SHEET COATING, ALUMINUM OR STEEL ENDS, SUBJECT TO NSPS IN 1981[a,b]
(gigajoules)

	Base case	Emission control option	
		IVA	IVB
Electricity	2,654	1,735	1,505
Natural gas	249,191	302,507	246,098
Total	251,845	304,241	247,602
Reduction due to NSPS		(52,395)	4,243

[a] VOC concentration in ventilating air is ppmv 100 as xylene. Affected capacity is based on 3.5 billion steel ends and 17.4 billion aluminum ends subject to NSPS in 1985.

[b] Figures in parentheses indicate an increase in energy requirements over the base case.

TABLE 7-26. BEVERAGE CAN SURFACE COATING: NET REDUCTIONS IN ENERGY REQUIREMENTS FROM REGULATORY ALTERNATIVES (gigajoules per year in 1985)

Source	Regulatory alternative I	Regulatory alternative II	Regulatory alternative III
Two-piece steel and aluminum can integrated facilities	0	26,847	884,444
Three-piece can sheet coating	0	4,499	32,830
Three-piece can forming	0	39	1,039
Steel or aluminum end sheet coating	0	4,243	4,243
Steel or aluminum end forming	0	0	0
Total	0	35,658	922,556

The quantities of petroleum-derived organic solvent materials used for solvent-borne base case coatings are reduced by low-solvent waterborne and eliminated by UV curing and no-varnish ink control options.

7.6 OTHER ENVIRONMENTAL CONCERNS

7.6.1 Irreversible and Irretrievable Commitment of Resources

Other than those resources initially required to construct incineration add-on control systems, or special ovens for UV-curing coatings, there do not appear to be any irreversible or irretrievable commitments of resources associated with the can coating control options.

7.6.2 Environmental Impact of Delayed Standards

Delayed implementation of emission control standards for beverage can coatings will have a negative environmental effects on emissions of VOC to the atmosphere, negative impacts on energy and petroleum resources, and minor or no positive impacts on water and solid waste.

7.7 REFERENCES

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6. Metal Bulletin. May 19, 1978. p. 23.

7. Packaging Trends, Modern Packaging. June 1978. p. 10.

8. Business Climate Outlook 1981-1985: A 5-Year Projection of the Economy, Energy, Selected Industries and Materials. American Can Company. April 1980. pp. 37-40.

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8. ECONOMIC IMPACT

8.1 INDUSTRY CHARACTERIZATION

The metal can industry is defined in the Standard Industrial Classification Manual under SIC 3411 as establishments primarily engaged in manufacturing metal cans from purchased materials. Metal cans include: food, milk, oil, beer, and general line containers; aluminum cans; tin cans; packers' cans; tinned pails; and other pails, except shipping and stamped.

Metal cans are used to package beverage, food, and nonfood products. They are normally made of steel or aluminum, and are often coated inside and/or outside for protective or decorative purposes.

The largest market for cans of a similar size and shape is in soft drink and beer containers. The popular sizes of these cans are 12-ounce and 16-ounce capacities. The beverage can is coated on the interior to protect the contents and on the exterior to provide decoration and product brand identification. Coating materials are designed to meet a variety of performance requirements. The high degree of sophistication in this coating and decorating technology is made possible by the large market for these cans.

The metal can industry is made up of approximately 100 companies with nearly 500 plants at 300 locations in the United States. Major producing areas are east, north central, Pacific, and middle Atlantic states.[1] Geographical distribution of can plants is shown in Figure 8-1.[2]

There are two general types of metal can plants: merchant vendor plants and captive plants. Merchant vendor plants produce a wide variety of two- and three-piece cans for sale to the beer and soft drink industry and to food and nonfood packagers. Captive plants are owned by bottlers or food processors and manufacture cans for use by the parent company or its subsidiaries. Approximately 30 percent of all cans are captively produced by food companies such as Campbell Soup, H. J. Heinz, and General Foods and

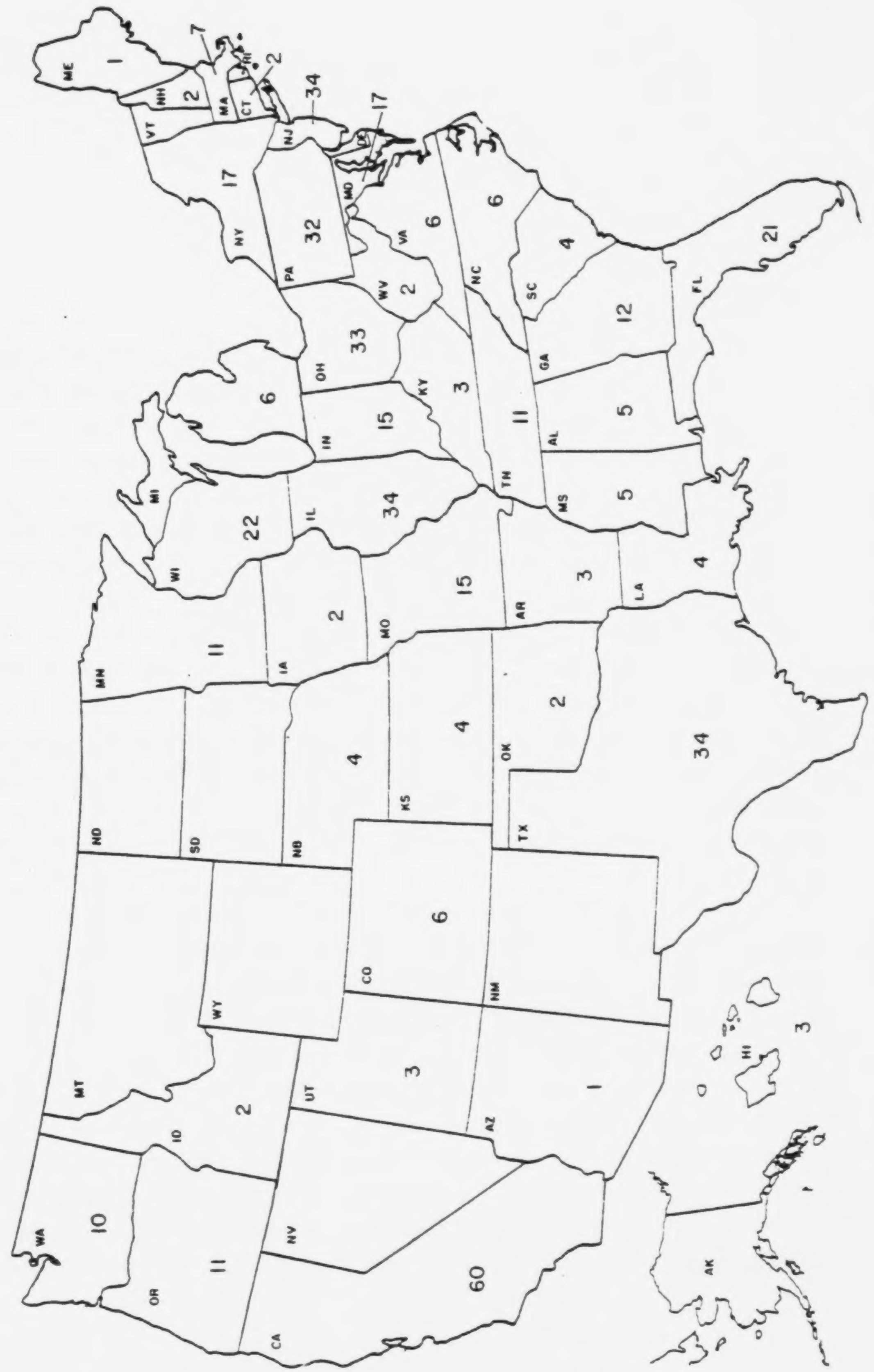

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Figure 8-1. Geographical Distribution of Can Manufacturing Plants.

by major breweries such as Adolph Coors, Schlitz, Carlings, Anheuser-Busch and Miller. Most captive beverage can plants are owned by breweries and produce only 12-ounce and 16-ounce steel or aluminum two-piece beer cans. Some merchant vendor plants are, in effect, captive because their facilities serve a particular brewery.

Table 8-1 lists the major U.S. merchant producers of metal cans and their can sales for 1975. This does not include producers of cans for captive use.

The can industry is highly concentrated. In 1975 the two major producers, Continental Group and American Can, accounted for approximately 37 percent of the value of all can shipments. National Can and Crown Cork and Seal accounted for another 14 percent.

Continental Group, founded in 1904, is the largest metal can manufacturer, presently employing 18,000 people in 91 can-manufacturing plants in the United States. Continental operates 20 two-piece beverage can lines that use aluminum as the primary raw material.

American Can, the second largest can manufacturer, has 27 beverage can plants located in 15 states, and 30 food-packaging plants manufacturing metal composite cans in 16 states. American Can manufactures both two-piece and three-piece beverage cans.

The third largest can manufacturer, National Can, operates 41 plants throughout the country for both food and nonfood packaging. Crown Cork and Seal, the fourth largest can company, manufactures and sells cans, crowns, closures and packaging machinery. It has 26 plants in the United States.

These companies and others have made major contributions to can packaging development. While the three-piece can has been used for packaging beverages for over 40 years, the development of two-piece cans is a comparatively new technology.

Manufacture of two-piece cans began in 1958 when Kaiser Industries made a two-piece, 7-ounce beer can. In 1959 Adolph Coors Co. introduced the first aluminum can for beer. Reynolds Metals Co. had developed machinery for high-speed manufacture of two-piece cans by 1963, and in 1971, Crown Cork & Seal introduced tin-plated steel two-piece cans. In 1972, Continental Can, now Continental Group, installed the first UV printer for cans. American Can developed a two-piece can in 1975 that was 30 percent

TABLE 8-1. MAJOR U.S. MERCHANT PRODUCERS OF METAL CANS, 1975[3]

Rank	Company	Million $
1	Continental Group	1,175
2	American Can Co.	1,125
3	National Can Co.	535
4	Crown Cork & Seal	315
5	Reynolds Metals	150
6	Ball Corp.	70
7	Diamond International	60
8	Van Dorn	60
9	Kaiser Aluminum & Chemical	55
10	J. L. Clark	30
11	Sherwin-Williams	30
	Other merchant suppliers	1,020
	Captive producers	1,545
	TOTAL	6,170

lighter than three-piece cans and, soon afterward, Alcoa introduced a reduced-diameter, taller, lightweight, two-piece can. Continuing improvements in can manufacturing are expected as manufacturers strive to keep ahead of competitive packaging.

In 1978 there were 48,500 production workers in the can industry. This represented a decrease of 19 percent from 1973, when 60,200 production workers were employed in the industry. Between 1977 and 1978 the number of production workers declined 0.4 percent. Total workers in the industry declined 16 percent between 1973 and 1978, dropping from 69,800 to 58,500 workers. This gradual reduction in employment can be attributed to the closing of marginal facilities and the installation of more efficient equipment, particularly the replacement of three-piece can lines with two-piece can facilities.

Plant sizes in terms of employment vary with the types of cans produced, the number of lines and degree of integration of systems. Two-piece beverage can plants are more automated than the older three-piece can operations. Some plants specialize in coating body sheets and end sheets for three-piece steel cans. The precoated sheets are sent to other plants for final forming into cans. Sheet plants usually employ about 120 people. Plants that have three-piece can sheet-coating and bodymaking operations may have a work force of 700 to 800 people, including administrative staff. More modern two-piece canmaking facilities may employ about 200 people. Employees in coating operations typically comprise about 6 to 15 percent of the work force.

Capital investment for beverage can plants has recently been reported to range from $20 million, for plants making two-piece steel cans at the rate of 800 million per year, to $37.5 million, for plants making combinations of two sizes of two-piece cans and ends.[4]

The Department of Commerce forecasts total can shipments of 92.9 billion with a value of $9,775 million for 1979, an increase of 14 percent over 1978.[5] Shipments of beverage cans in 1979 are estimated to be 65 billion units with a value of $3.5 billion.

Shipments of beverage cans have increased steadily since 1967, accounting for a greater share of the metal can market. Annual value and quality of metal cans since 1972 are shown in Table 8-2. Also included are the

TABLE 8-2. ANNUAL SHIPMENTS OF METAL CANS - VALUE AND QUANTITY[1]
1972-1979

Year	Value of shipments, billion $	% change, year to year	Number of cans, billions	% change, year to year	Number of steel cans, billions	% change, year to year	Number of aluminum cans, billions	% change, year to year
1972	4.224	---	77.844	---	67.672	---	10.172	---
1973	4.661	+10.3	83.326	+7.0	71.083	+5.0	12.243	+20.4
1974	5.596	+20.1	86.441	+3.7	71.251	+0.2	15.190	+24.1
1975	6.349	+13.5	81.151	-6.1	63.588	-10.8	17.563	+15.6
1976[a]	6.842	+7.8	83.972	+3.5	61.907	-2.6	22.065	+25.6
1977[a]	7.775	+13.6	88.3	+5.1	NA[c]	NA	NA[c]	NA
1978[a]	8.610	+10.7	90.4	+2.4	NA[c]	NA	NA[c]	NA
1979[b]	9.775	+13.5	92.9	+2.8	NA	NA		

[a] Estimated by Bureau of Domestic Commerce

[b] Forecast by Bureau of Domestic Commerce

[c] This information is not available for 1979. Previously reported steel can shipments are about double the shipments of aluminum cans.

annual quantities of steel and aluminum cans and year-to-year percentage changes.

The major products that are packaged in metal cans are shown in Table 8-3. Between 1967 and 1977, cans used to package beverages grew from 37 to 58 percent of the cans produced. Increased use of cans to package beverages is expected to continue. Production of food and nonfood cans has been essentially static since 1967.

Beverage can shipments from 1971 to 1978 are shown in Table 8-4. All of the aluminum cans are two-piece. Approximately 40 percent, or 9.8 billion, of the steel cans shipped in 1978 were two-piece. The remaining 14.5 billion steel cans were of three-piece construction.[6]

Conservative estimates predict a 2.2 percent compound annual growth in the unit shipments of all metal cans[1] between 1977 and 1982. Other sources project increases of between 3.3 and 3.9 percent per year through 1990.[7] [8] Most of this growth will take place in containers for beer and soft drinks. One estimate places the compound annual growth rate for all beverage cans at 5.5 percent, from 51 billion cans in 1977 to nearly 80 billion cans in 1985.[9] Another source forecasts compound annual increases in can shipments of approximately 7 and 5.5 percent for soft drink and beer cans, respectively, through 1980.[10] Food cans are expected to grow at less than 1 percent through 1990,[11] and nonfood cans should continue a slow decline. Estimates of aluminum beverage can growth range from 5 to 8 percent per year through 1985, while steel can unit production is expected to increase at roughly 2 percent per year over the same period.[9] [12]

A review of Table 8-4 shows that over the past 6 to 8 years nearly all of the growth in the beverage can industry has been in two-piece aluminum cans. As the above projections indicate, this trend is expected to continue, particularly for beer cans. Two-piece aluminum is expected to represent approximately 95 percent of the beer can market by 1980.[1]

While aluminum is still the dominant two-piece package, use of steel two-piece cans is increasing. Presently, approximately 20 percent of two-piece cans are estimated to be steel, and this share is expected to increase to 30 percent by 1980.[1] The lower price per pound for steel has been the main incentive for this change.

TABLE 8-3. METAL CAN SHIPMENTS[13][14]

Commodity packaged	(Million units) 1967	1972	1973	1974	1975	1976	1977
Food-beverage							
Fruit and fruit juices	5,725	5,788	5,776	5,720	5,304	5,111	5,358
Vegetable and vegetable juices	8,781	10,200	10,462	11,117	10,683	9,736	10,819
Evaporated and condensed milk	1,668	1,420	1,312	1,982	1,882	1,956	1,533
Other dairy products	1,428	203	188	---	---	---	---
Meat and poultry	1,653	1,733	1,826	1,774	1,649	1,683	1,813
Fish and seafoods	1,718	1,660	1,737	1,883	1,377	1,241	1,177
Lard and shortening	348	296	423	486	587	660	347
Baby food and formulas	534	840	741	855	769	826	785
All other foods and soups	5,087	5,473	7,855	8,350	7,561	7,303	6,673
Total foods	25,942	27,613	30,320	32,167	29,812	28,516	28,505
Soft drinks	7,290	15,265	17,607	17,492	16,311	19,564	23,643
Beer	13,768	22,126	23,844	25,874	25,953	26,268	27,650
Coffee	946	839	824	782	798	794	538
Total beverages	22,004	38,230	42,275	44,148	43,062	46,626	51,741
Pet foods	2,898	3,567	3,770	3,700	3,001	3,111	2,899
Aerosols	1,900	2,857	3,098	2,957	2,249	2,378	2,076
Nonfood							
Oil (open top through 5 qt.)	826	874	784	644	596	647	601
Pail, varnish	716	834	826	809	768	873	756
All other nonfoods	2,577	3,219	2,141	2,016	1,663	1,831	1,732
Total nonfoods	4,119	4,927	3,751	3,469	3,027	3,351	3,089
Total cans	56,863	77,194	83,215	86,441	81,151	83,982	88,310
(Soft drinks and beer) Beverage as a percent of total	37	48	50	50	52	55	58

TABLE 8-4. BEVERAGE CAN SHIPMENTS[6, 10, 14]

	Soft drink cans				Beer cans			
Year	Total cans, billions	% change year to year	Total steel, billions	Total aluminum, billions	Total cans, billions	% change year to year	Total steel, billions	Total aluminum, billions
1971	14.1	---	12.9	1.2	20.2	---	15.2	5.0
1972	15.3	8.5	13.9	1.4	22.1	9.4	15.4	6.7
1973	17.6	15.0	15.9	1.7	23.8	7.7	14.9	8.9
1974	17.5	-0.6	15.5	2.0	25.9	8.8	14.0	11.9
1975	16.5	-5.7	14.0	2.5	26.1	0.8	12.3	13.8
1976	19.5	18.2	15.1	4.5	26.9	3.1	10.4	16.5
1977	23.3	19.6	16.7	6.9	27.9	0.4	9.0	18.9
1978	25.5	9.0	16.0	9.5	28.9	0.4	8.3	20.5

The continued trend toward two-piece beverage cans is related to lower labor requirements in manufacture, reduced material needs because of thinner sidewalls, better graphics, and convenient recycling for aluminum cans.[1]

8.2 COST ANALYSIS OF CONTROL OPTIONS

8.2.1 Introduction

Considerations pertaining to the definition of model plants and to the selection of regulatory alternatives are discussed in detail in section 6.0. A brief summary of these topics is presented here to support the analysis of control option costs.

In order to analyze a large segment of beverage can surface-coating operations, model plants have been defined for both two-piece and three-piece beverage can operations. The scale of can production for the model plants is:

Type of Plant	Annual Can Production
Small-scale two-piece	400 million
Large-scale two-piece	2,400 million
Small-scale three-piece	400 million
Large-scale three-piece	800 million

The coating operations associated with these plants and included in this cost analysis are:

- Two-piece aluminum- or steel-can integrated facility

  Exterior base coat
  Lithography and overvarnish
  Interior spray

- Three-piece steel-sheet coating

  Exterior base coat
  Interior base coat
  Lithography and overvarnish

- Three-piece steel-can forming

  Interior spray

- Sheet coating, steel or aluminum ends

  Exterior base coat
  Interior base coat

The control options evaluated for these operations are summarized in Tables 8-5 through 8-8. These options are evaluated relative to the emis-

TABLE 8-5. EVALUATED OPTIONS FOR CONTROL OF VOC EMISSIONS FROM COATING OPERATIONS AT INTEGRATED TWO-PIECE CAN-FORMING LINES (ALUMINUM AND STEEL)[a]

	Base case	Option IA	Option IB	Option IC	Option ID
VOC emissions reduction, %	0	46	58	50	61
Exterior base coat					
Type of coating	waterborne	solvent-borne	solvent-borne	waterborne	waterborne
kg VOC/litre solids	0.54	1.00	1.00	0.29	0.29
Incineration	none	cure oven and coater	cure oven and coater	none	none
Lithography/overvarnish					
Type of coating	waterborne	solvent-borne	no-varnish inks	waterborne	no-varnish inks
kg VOC/litre solids	0.53	2.55	0	0.46	none
Incineration	none	cure oven and coater	none	none	none
Inside spray					
Type of coating	waterborne	solvent-borne	solvent-borne	waterborne	waterborne
kg VOC/litre solids	1.24	3.01	3.01	0.89	0.89
Incineration	none	cure oven, coater and flashoff	cure oven, coater and flashoff	none	none

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[a] VOC content of solvent-borne coatings is as applied and before control.

TABLE 8-6. EVALUATED OPTIONS FOR CONTROL OF VOC EMISSIONS FROM COATING OF STEEL SHEET FOR THREE-PIECE CANS

	Base case	Option IIA	Option IIB	Option IIC	Option IID
VOC emissions reduction, %	0	32	41	34	49
Exterior base coat					
Type of coating	waterborne	solvent-borne	solvent-borne	waterborne	waterborne
kg VOC/litre solids	0.54	1.00	1.00	0.50	0.50
Incineration	none	coater, flash-off and cure oven	coater, flash-off and cure oven	none	none
Interior base coat					
Type of coating	waterborne	solvent-borne	solvent-borne	waterborne	waterborne
kg VOC/litre solids	0.53	3.30	3.30	0.50	0.50
Incineration	none	cure oven, flashoff, and coater	cure oven, flashoff, and coater	none	none
Lithography/overvarnish					
Type of coating	waterborne	solvent-borne	no-varnish inks	waterborne	no-varnish inks or UV cure
kg VOC/litre solids	0.53	1.47	-	0.46	-
Incineration	none	cure oven, flashoff, and coater	none	none	none

[a] VOC content of solvent-borne coatings is as applied and before control.

TABLE 8-7. EVALUATED OPTIONS FOR CONTROL OF VOC EMISSIONS FROM COATING OPERATIONS AT THREE-PIECE CAN FORMING LINES, INSIDE SPRAY[a]

	Base case	Option IIIA	Option IIIB
VOC emissions reduction, %	0	45	28
Inside spray			
Type of coating	waterborne	solvent-borne	waterborne
kg VOC/litre solids	1.24	3.01	0.64
Incineration	none	coater, flash-off, and cure oven	none

[a] VOC content of solvent-borne coatings is as applied and before control.

TABLE 8-8. EVALUATED OPTIONS FOR CONTROL OF VOC EMISSIONS FROM COATING OF STEEL- AND ALUMINUM-ENDS FOR THREE-PIECE CANS[a]

	Base case	Option IVA	Option IVB
VOC emissions reduction, %	0	31	33
Exterior coating			
Type of coating	waterborne	solvent-borne	waterborne
kg VOC/litre solids	0.53	1.04	0.50
Incineration	none	coater, flashoff and cure oven	none
Interior coating			
Type of coating	waterborne	solvent-borne	waterborne
kg VOC/litre solids	1.24	3.30	0.50
Incineration	none	coater, flashoff and cure oven	none

[a] VOC content of solvent-borne coatings is as applied and before control.

sion limitations recommended in the CTG for the base case. As explained in chapter 6.0, these limitations are being widely adopted by states for their SIP's.

Tables 8-9 through 8-12 summarize additional parameters of the model plants with estimated capital and operating costs for new facilities. These are only the incremental costs associated with the coating systems and emission control systems; that is, no "front-end" or "back-end" equipment costs are included. Both capital and operating costs have mid-1978 bases. The costs shown do not include any recovery of capital investment. Further discussions of these costs and the assumptions and bases used in the cost analysis are included in section 8.2.2.1.

Costs for the base case and control options for the application of end-sealing compounds are essentially the same. No changes in equipment are required. Costs of solvent-based and water-based end-sealing compounds are comparable. The option using water-based materials does not require ventilating air. However, the energy savings are minimal. Consequently, no option selected would have an economic impact.

8.2.2 New Facilities

As previously discussed in section 6.1.1, recently constructed two-piece can plants have included two to six lines. Consequently, the small-scale model plants were defined as having two lines and the large-scale plants as having six lines so that the cost analysis would be relevant to current plant design practices.

Because of the industry trend toward increased manufacture of two-piece cans, the task of defining model three-piece can plants is less certain. However, large-scale and small-scale model three-piece plants have been defined that have capacities similar to existing plants and represent a range of capacities into which any new three-piece plants would likely fall. A more detailed discussion of the rationale for the definition of these plants is given in section 6.1.2.

In addition to the costs of new facilities, model plant parameters such as production rates, operating hours, emission rates, and emission reductions are given in Tables 8-9 through 8-12.

8.2.2.1 Capital Costs. The capital costs given in Tables 8-9 through 8-12 include the cost of coating systems and emission control systems, but

TABLE 8-9. COST DATA, TWO-PIECE ALUMINUM AND STEEL INTEGRATED FACILITY[a]

				Small scale[b] (400,000,000 cans/yr)				Large scale[c] (2,400,000,000 cans/yr)			
	Emissions (kg /1,000 cans)			Emissions (Mg/yr)				Emissions (Mg/yr)			
Regulatory options	Coater and flashoff	Oven	Total	Total	Reduction from base case	Capital cost ($$10^3$)	Annual operating cost ($$10^3$/yr)	Total	Reduction from base case	Capital cost ($$10^3$)	Annual operating cost ($$10^3$/yr)
Base case (waterborne)											
Exterior base coat	0.103	0.034	0.137	55	-	1,650	664	328	-	4,950	4,130
Lithography/overvarnish	0.041	0.013	0.054	22	-	1,860	490	130	-	5,590	2,950
Inside spray	0.161	0.040	0.201	80	-	1,050	562	482	-	3,510	3,470
Total	0.305	0.087	0.392	157	-	4,560	1,716	940	-	14,050	10,550
Option IA (solvent-borne, incineration coater and cure oven exhausts)											
Incineration						205	56			225	357
Exterior base coat	0.047	0.029	0.076	30	25	1,650	720	182	146	4,950	4,500
Lithography/overvarnish	0.045	0.028	0.073	29	7	1,860	560	175	(45)	5,590	3,390
Inside spray	0.069	0.017	0.086	35	45	1,650	646	207	275	3,510	4,470
Total	0.161	0.074	0.235	94	63	4,765	1,982	564	376	14,275	12,717
Option IB (solvent-borne, incineration coater and cure oven exhausts, no-varnish ink)											
Incineration						200	81			218	277
Exterior base coat	0.047	0.029	0.076	30	25	1,650	720	182	146	4,950	4,500
Lithography/overvarnish	0.0	0.005	0.005	2	20	502	294	12	118	1,510	1,730
Inside spray	0.069	0.017	0.086	35	45	1,050	646	207	275	3,510	4,470
Total	0.116	0.051	0.167	67	90	3,402	1,741	401	539	10,188	10,977
Option IC (waterborne)											
Exterior base coat	0.050	0.017	0.073	29	26	1,650	664	175	153	4,950	4,130
Lithography/overvarnish	0.035	0.012	0.047	19	3	1,860	490	113	17	5,590	2,950
Inside spray	0.066	0.016	0.148	59	21	1,050	662	355	127	3,510	3,470
Total	0.151	0.045	0.267	107	50	4,560	1,716	643	297	14,050	10,550
Option ID (waterborne and no-varnish ink)											
Exterior base coat	0.050	0.017	0.073	29	26	1,650	664	175	153	4,950	4,130
Lithography/overvarnish	0.0	0.005	0.005	2	20	502	294	12	118	1,510	1,730
Inside spray	0.066	0.016	0.148	59	21	1,050	562	355	127	3,510	3,470
Total	0.116	0.038	0.226	90	67	3,202	1,520	398	408	9,970	9,330

[a] Annual operating cost includes taxes and insurance at 2 percent of capital investment and administration and permits at 2 percent of capital investment. Capital costs include cost of coating systems and emission control systems only. They do not include front and back end costs.

[b] Two lines at 700 cans/min operating 4,700 hours per year. Annual production is 400 million cans.

[c] Six lines at 800 cans/min operating at 8,400 hours per year. Annual production is 2,400 million cans.

TABLE 8-10. COST DATA, THREE-PIECE STEEL-SHEET COATING FACILITY[a]

Regulatory options	Emissions (kg /1,000 cans)			Small scale[b] (400,000,000 can equivalents/yr)				Large scale[c] (800,000,000 can equivalents/yr)			
				Emissions (Mg/yr)				Emissions (Mg/yr)			
	Coater and flashoff	Oven	Total	Total	Reduction from base case	Capital cost ($\$10^3$)	Annual operating cost ($\$10^3$/yr)	Total	Reduction from base case	Capital cost ($\$10^3$)	Annual operating cost ($\$10^3$/yr)
Base case (waterborne)											
Exterior base coat	0.014	0.128	0.142	58	-	708	197	114		1,415	369
Interior base coat	0.005	0.041	0.046	18	-	707	566	37		1,415	1,110
Lithography/overvarnish	0.005	0.041	0.046	18	-	1,415	243	37		2,830	486
Total	0.023	0.311	0.234	94	-	2,830	1,006	188		5,660	1,965
Option IIA (solvent-borne and incineration)											
Incineration						197	41			210	140
Exterior base coat	0.020	0.010	0.030	12	46	708	276	24	90	1,415	525
Interior base coat	0.021	0.008	0.029	11	7	707	494	23	14	1,415	964
Lithography/overvarnish	0.011	0.003	0.014	6	12	1,415	210	11	26	2,830	420
Total	0.052	0.021	0.073	29	65	3,027	1,021	58	130	5,870	2,049
Option IIB (solvent-borne, incineration, no-varnish inks, or UV cure)											
Incineration						190	32			200	121
Exterior base coat	0.020	0.010	0.030	12	46	708	276	24	90	1,415	525
Interior base coat	0.021	0.008	0.029	11	7	707	494	23	14	1,415	964
Lithography/overvarnish	0	0.005	0.005	2	16	1,134	132	4	33	2,268	264
Total	0.041	0.023	0.064	26	68	2,739	934	51	137	5,298	1,874
Option IIC (waterborne)											
Exterior base coat	0.013	0.118	0.131	52	6	708	197	105	9	1,415	369
Interior base coat	0.004	0.040	0.044	18	0	707	566	35	2	1,415	110
Lithography/overvarnish	0.004	0.036	0.040	16	2	1,415	243	32	5	2,830	486
Total	0.021	0.194	0.215	86	8	2,830	1,006	172	16	5,660	965
Option IID (waterborne, no-varnish inks, or UV cure)											
Exterior base coat	0.013	0.118	0.131	52	6	708	197	105	9	1,415	369
Interior base coat	0.004	0.040	0.044	18	0	707	566	35	2	1,415	110
Lithography/overvarnish	0	0.005	0.005	2	16	1,134	132	4	33	2,268	264
Total	0.017	0.163	0.180	72	22	2,549	895	144	44	5,098	753

[a] Annual operating cost includes taxes and insurance at 2 percent of capital investment and administration and permit at 2 percent of capital investment. Capital cost includes cost of coating systems and emission control systems only. They do not include front end equipment and back end equipment costs.

[b] One line at 90 sheets/min operating 4,240 hrs/yr split between exterior and interior coating and one line at 90 sheets/min operating 2,120 hrs/yr for lithography/overvarnish.

[c] Two lines at 110 sheets/min operating 3,460 hrs/yr split between exterior and interior coating and two lines at 90 sheets/min operating 2,120 hrs/yr for lithography/overvarnish.

TABLE 8-11. COST DATA, THREE-PIECE STEEL INSIDE SPRAY[a]

				Small scale[b] (400,000,000 cans/yr)				Large scale[c] (800,000,000 cans/yr)			
	Emissions (kg /1,000 cans)			Emissions (Mg/yr)				Emissions (Mg/yr)			
Regulatory options	Coater and flashoff	Oven	Total	Total	Reduction from base case	Capital cost ($$10^3$)	Annual operating cost ($$10^3$/yr)	Total	Reduction from base case	Capital cost ($$10^3$)	Annual operating cost ($$10^3$/yr)
Base case (waterborne)											
Inside spray	0.166	0.041	0.207	83	-	1,580	563	166	-	2,100	985
Option IIIA (solvent-borne and incineration)											
Incineration						186	28			200	67
Inside spray	0.069	0.017	0.086	34	49	1,580	586	69	97	2,100	1,130
Total						1,766	614			2,300	1,197
Option IIIB (High solids waterborne)											
Inside spray	0.086	0.021	0.107	43	40	1,580	513	86	80	2,100	985

[a] Assumes three-piece inside spray costs similar to two-piece inside spray costs. Annual operating costs include taxes and insurance at 2 percent of capital investment and administration and permit at 2 percent of capital investment. Capital costs include costs of coating systems and emission control systems only. They do not include front end and back end equipment costs.

[b] One line at 2,160 cans/min operating for 3,090 hr/yr. Annual production 400 million cans.

[c] Two lines at 1,080 cans/min operating for 4,120 hr/yr. Annual production 800 million cans..

TABLE 8-12. COST DATA, SHEET COATING, STEEL AND ALUMINUM ENDS[a] (1,100,000,000 ends/year)

Regulatory option	Emissions (kg/1,000 ends) Coater and Flashoff	Oven	Total	Emissions[b] (Mg/yr) Total	Reduction from base case	Capital cost ($$10^3$)	Annual operating cost ($$10^3$)
Base case (waterborne)							
Exterior coating	0.0004	0.0038	0.0042	5	-	708	115
Interior coating	0.0026	0.0237	0.0263	29	-	707	329
Total	0.0030	0.0275	0.0305	34	-	1,415	444
Option IVA (solvent-borne and incineration coater, flashoff and cure oven exhaust)							
Incineration						180	20
Exterior coating	0.0012	0.0004	0.0016	2	3	708	160
Interior coating	0.0089	0.0032	0.0121	13	14	707	287
Total	0.0101	0.0036	0.0137	15	17	1,595	467
Option IVB							
Exterior coating	0.0004	0.0036	0.0040	4	1	708	115
Interior coating	0.0010	0.0095	0.0105	12	17	707	329
Total	0.0014	0.0131	0.0145	16	18	1,415	444

[a] Capital cost assumed to be similar to three-piece sheet capital costs. Operating cost is also similar but 20 percent smaller because of smaller sheet size. Annual operating cost includes taxes and insurance at 2 percent of capital investment and administration and permit at 2 percent of capital investment. Capital costs include costs of coating systems and emission control systems only. They do not include front end and back end equipment costs.

[b] One line, split between exterior and interior at 90 sheets/min operating for 3,080 hr/yr. Annual production 1.1 billion ends/yr.

they do not include capital costs of other can-line equipment. The costs were developed using a mid-1978 basis from the sources referenced in Table 8-13.

Tables 8-9 through 8-12 give the capital costs for coating and emission control systems for each coating operation of each control option, for both small-scale and large-scale model plants. In addition to comparisons between options, these costs may also be compared to the cost of implementing CTG recommendations (the base case). Most states are adopting the CTG limits for their State Implementation Plans.

8.2.2.2 Operating Costs. The operating costs indicated in Tables 8-9 through 8-12 were also developed using a mid-1978 basis. The coating materials costs used in the analysis are shown in Table 8-14.[21]

Other operating cost parameters used in the analysis are indicated in Table 8-15.

8.2.2.3 Base Cost of Facility. Maximum economic impact and minimum negative environmental impact will occur if growth in beverage can requirements is satisfied by the construction of new two-piece facilities subject to NSPS.

Capital costs for the construction of a two-piece beverage can plant are estimated at approximately $30 (1979 dollars) per 1,000 cans annual capacity.[22] [23] [24] Annual operating costs, including annualized capital costs, are estimated at $50 per 1,000 cans manufactured.[24] [25] Using these figures, the estimates of capital and operating requirements shown in Table 8-16 can be calculated. Incremental capital and annual operating costs (less annualized capital costs) are also shown in Table 8-16. These cost data represent the additional costs above those required to attain the emission levels specified in the base case.

8.3 OTHER COST CONSIDERATIONS

The can manufacturing industry is currently obligated to comply with water and OSHA regulations. The costs associated with compliance with other regulations are not judged to significantly affect the analysis contained in section 8.5.

8.4 ECONOMIC IMPACTS

This section presents the estimated impacts of the regulatory alternatives on new production facilities in the beverage can industry. Three

TABLE 8-13. SOURCES OF COST DATA FOR COATING AND EMISSION CONTROL SYSTEMS

Coating or control system	Reference no.
Solvent-borne coating	15,16,17
Waterborne coating	15,16,17
High-solids coating	15,16
Ultraviolet-cured coating	15,16
No-var ink utilization	15,16
Thermal incineration	18,19,20

TABLE 8-14. SCHEDULE OF COATING MATERIAL COSTS[21]
($/gal)

Operation	Interior base coat	Exterior base coat	Overvarnish	Inside spray
Three-piece steel cans				
Solvent-borne coating	4.50	6.50	4.75	
Waterborne coating	5.25	7.25	5.50	
High-solids coating	10.00	10.00		
UV-cured coating			17.00	
No-var ink			7.00	
Two-piece aluminum cans				
Solvent-borne coating	6.25		5.25	4.00
Waterborne coating	5.25		5.10	4.00
High-solids coating	10.00			
UV-cured coating			17.00	
No-var ink			7.00	

TABLE 8-15. PARAMETERS USED TO DERIVE OPERATING COSTS

Operating labor	
Operator	$12/h
Supervision	15% operating labor charge
Maintenance	
Labor	$14/h
Materials	Equal to labor
Utilities	
Electricity	$0.033kWh
Steam	$5/M lb
Natural gas fuel	$3/MM Btu
Recovered solvent value	$0.085/lb

TABLE 8-16. CAPITAL AND OPERATING COSTS REQUIRED TO MEET GROWTH IN DEMAND FOR TWO-PIECE BEVERAGE CANS
(1979 dollars)

	Year					
	1981	1982	1983	1984	1985	Total
Basic plant						
Increased demand, billion cans	3.68	3.92	4.17	4.40	4.71	20.88
Capacity requirements, billion cans	4.09	4.36	4.63	4.89	5.23	23.20
Capital costs, 10^6 $	122.7	130.8	138.9	146.7	156.9	696.0
Cumulative capital costs, 10^6 $	122.7	253.5	392.4	539.1	696.0	
Annualized capital costs, 10^6 $[a]	21.0	22.4	23.8	25.1	26.8	119.1
Cumulative annualized capital costs	21.0	43.4	67.2	92.3	119.1	
Operating costs (including annualized capital costs, 10^6 $	184.0	196.0	208.5	220.0	235.5	1,044.0
Operating costs (excluding annualized capital costs), 10^6 $	163.0	173.6	184.7	194.9	208.7	924.9
Cumulative operating costs	163.0	336.6	521.3	716.2	924.9	
Incremental costs to meet NSPS emission limitation						
Capital costs, 10^6 $	8.8	9.4	10.0	10.5	11.3	50.0
Cumulative capital costs, 10^6 $	8.8	18.2	28.2	38.7	50.0	
Annualized capital costs, 10^6 $[a]	1.5	1.6	1.7	1.8	1.9	8.5
Cumulative annualized capital costs	1.5	3.1	4.8	6.6	8.5	
Operating costs (excluding annualized capital costs), 10^6 $	0.8	0.9	0.9	1.0	1.1	4.7
Cumulative operating costs, 10^6 $	0.8	1.7	2.6	3.6	4.7	

[a] Based on a 15-year recovery period and 15 percent interest factor.

regulatory alternatives were described in Chapter 6: no regulation (Alternative I), a regulation based on the best available waterborne coatings (Alternative II), and a regulation based on the best available waterborne coatings with no-varnish inks or UV cure for the lithography/overvarnish coating operation (Alternative III). Alternative I would obviously have no economic impact on the industry; therefore, only the impacts of Alternatives II and III are considered in this section.

Impacts are estimated for four types of production facilities: two-piece aluminum or steel can fabrication, three-piece sheet coating, three-piece can forming, and steel end coating and fabrication for three-piece cans.* The specific techniques, or control options, that can be used to comply with the regulatory alternatives were also described in Chapter 6. The costs of each control option for the four facilities were presented in section 8.2. Since there is no lithography/overvarnish coating step in the three-piece can forming and the steel end coating facilities, the impacts of Alternatives II and III are identical for these facilities. Thus, the choice of one of these alternatives as the basis for the standard would affect only the three-piece sheet coating and two-piece integrated facilities.

An analysis of the cost data in section 8.2 is combined with the industry profile data in section 8.1 to determine the economic impacts of the regulatory alternatives. In particular, impacts on product price, return on investment, and additional capital required by the industry to comply with the regulatory alternatives are estimated. Changes in industry growth and structure are treated qualitatively. A summary of these impacts is presented in section 8.4.1. Section 8.4.2 describes the methodology that was used to determine the impacts. Section 8.4.3 contains the estimated impacts on each production facility of each regulatory alternative.

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*A fifth affected facility is the application of the sealing compound for steel and aluminum ends. However, the regulatory alternative would require the same level of control as the CTG, which the states use to develop their State Implementation Plans (SIPs). Thus, the regulatory alternative would have no impact on this facility, and it is ignored for the remainder of this analysis.

8.4.1 Summary

No economic impacts on the beverage can industry are likely to occur under any of the regulatory alternatives. Among the control options considered for each production facility, there is at least one whose cost is equal to or less than the cost of complying with the SIP, or "base case," level of control. Even if no regulation was proposed (Alternative I), the results show that firms building new production facilities have an economic incentive to achieve a greater level of control than is required by the SIPs, or are at least indifferent to a move towards a more stringent control level (e.g., when the cost of meeting the SIP standard and the cost of an option that further reduces emissions are identical). This is not to say that all of the control options have no impact on the affected facilities, only that options are available to each facility that would have no impact.

Incineration option A would have an effect on product price or return on investment (ROI), and would require an additional capital outlay by the firm. Under Regulatory Alternative II, firms building new small-scale facilities involved in the production of three-piece cans (sheet coating, can forming, and end coating) would have to increase the output price by 0.7 percent, or absorb the additional costs and accept a cut in the rate of return of 1.5 to 4.4 percentage points. Large-scale facilities would have to increase the output price by 0.9 percent, or accept a cut in the rate of return of 1.8 to 10.1 percentage points. Increases in capital requirements for the three types of production facilities (both small and large scale) range from 6 to 13 percent.

Three points must be noted concerning the estimated impacts for three-piece can production facilities. First, these impacts occur only under the most stringent incineration strategies. Other options are available to each of the production facilities that would have no impact; more specifically, it appears that firms have an economic incentive (either cost minimization or profit maximization) to adopt these options, even in the absence of a regulation. Second, these impacts would be smaller for an integrated three-piece facility (one with the sheet-coating, can-forming, and end-coating operations under one roof) than the sum of the impacts estimated for each separate facility. Only one incinerator would be required for the integrated facility; the cost data used in the analysis assume that each affected facility has an incinerator. Third, as discussed in section 8.1, it is extremely unlikely that any new three-piece can facilities will be constructed--the economics of two-piece beverage can production have rendered the three-piece can obsolete as far as future capacity expansion is concerned. Thus, no impacts are anticipated for this sector of the industry.

The only impacts of Alternative II on two-piece can production facilities occur when emissions from solvent-borne coatings used for the interior and exterior base coats and the lithography/overvarnish are incinerated (option A). This option would result in a price increase of less than 2 percent. If the additional costs were absorbed by the firm, small-scale producers (400 million cans per year) would see the ROI decline by about 6 percentage points. Additional capital outlays would amount to between 4 and 5 percent of the capital required to meet the SIP level of control for small-scale facilities, and would amount to less than 2 percent for large-scale producers. On the other hand, however, another incineration option (B) and and the waterborne coating options (C and D) would have no effect on price, ROI, or capital outlays. Under Alternative III, the control options would have no impact on firms investing in new facilities.

In conclusion, then, two key factors lead to a finding of "no impact" on the beverage can coating industry. First, it is very unlikely that any new three-piece can facilities will ever be constructed. Second, even if a new facility did come onstream, control options exist which enable the firm to meet the requirements of either regulatory alternative at a cost that is equal to or less than the cost of complying with existing SIP regulations. This second factor applies equally to new two-piece facilities under Alternative II; under Alternative III, none of the control options would have an adverse effect on the industry. Therefore, the regulatory alternatives should have no effect on the industry growth rate, nor will they alter the structure of the industry by forcing existing firms out of the market or by precluding new firms from entering.

8.4.2 Methodology

The methodology used to estimate the impacts of the regulatory alternatives is described in this section. A discounted cash flow (DCF) approach is used to evaluate the profitability of investing in new production facilities and, more specifically, to determine which of several alternative facilities is the most profitable for the firm. For a given type of production facility, the firm can choose one of several possible configurations. These configurations correspond to the "base case" and the control options for which cost data were provided in section 8.2. For example, a firm investing in a new two-piece can-forming facility has three configurations from which to choose: the "base case," which meets the SIP level of control, a solvent-borne coating line with an incinerator (control option A), and a line using best available waterborne coatings (control option B). Using the DCF approach, the most profitable configuration for each type of production facility can be selected. The resulting choices show which facilities would be constructed by the industry in the absence of the regulatory alternatives and thus constitute a baseline from which the impacts of those alternatives can be measured.

The remainder of this section is organized as follows. A general description of the DCF approach is provided in section 8.4.2.1. This background is needed in order to understand the particular application of the DCF approach presented in section 8.4.2.2 that is used to estimate the economic impacts. Finally, how the impacts are calculated using this method is discussed in section 8.4.2.3.

8.4.2.1 Discounted Cash Flow Approach. An investment project generates cash outflows and inflows. Cash outflows include the initial investment, operating expenses, and interest paid on borrowed funds. Cash inflows are the revenues from sales of the output produced by the project, depreciation of the capital equipment, and recovery of the working capital at the end of the project's life. Cash outflows and inflows can occur at any time during the project's lifetime. For this analysis, it is assumed that all flows take place instantaneously at the end of each year. Furthermore, it is assumed that all investments are conventional investments, that is, they are represented by one cash outflow followed by one or more cash inflows.[26] This assumption insures the existence of a unique internal rate of return for each project.[27] For a project with a lifetime of N years, there are N + 1 points in time at which cash flows occur: at the end of year zero, the end of year one, and so on until the end of the Nth year.

The initial (and only) investment is assumed to be made at the end of year zero. This cash outflow comprises the sum of the fixed capital cost and the working capital. It is offset by an investment tax credit, which is calculated as a percentage of the fixed capital cost and represents a direct tax saving. The cash flow in year zero can be given by the following equation:

$$Y_0 = (FCC + WC) - (TCRED \times FCC) \qquad (8\text{-}1)$$

The variables for this and subsequent equations are defined in Table 8-17.

The project generates its first revenues (and incurs further costs) at the end of year one. The net cash flows in this and succeeding years can be represented by the following equation:

$$Y_t = (R_t - E_t)\,(1 - T) + D_t T \qquad t = 1, \ldots, N \qquad (8\text{-}2)$$

The first term of equation 8-2 represents the after-tax inflows of the project generated by sales of the output after netting out all deductible expenses. Revenues are given by

$$R_t = P \cdot Q \cdot U \qquad (8\text{-}3)$$

Deductible operating expenses, E_t, are the sum of the fixed and variable operating costs and can be represented by

$$E_t = V \cdot U + F \qquad (8\text{-}4)$$

Variable costs include expenditures on raw materials, labor (operating, supervisory, and maintenance), and utilities. Fixed costs include expenditures for facility use, insurance, administrative overhead, etc. For income tax purposes, E_t is deductible from gross revenues, R_t. Hence, the after-tax cash inflow to the firm can be determined by netting out these expenses and multiplying the result by (1 - T).

Federal income tax laws also allow a deduction for depreciation of the capital equipment (not including working capital). Although depreciation is not an actual cash flow, it does reduce income tax payments (which are cash outflows) since taxes are based on net income after deducting the depreciation allowance.[28] The expression in equation 8-2, $D_t T$, represents the annual tax savings to the firm resulting from depreciation; it is treated as a cash inflow. In the analysis in this section, the straight

TABLE 8-17. DEFINITIONS

Symbol	Explanation
D_t	depreciation in year t
DF_t	discount factor = $(1+r)^{-t}$
DF	sum of the discount factors over the life of the project = $\sum_{t=0}^{N} (1+r)^{-t}$
DSL	present value of the tax savings due to straight line depreciation = $\sum_{t=0}^{N} D_t T(1+r)^{-t}$
E_t	operating expenses in year t
F	annual fixed costs
FCC	fixed capital costs
I_t	interest paid on borrowed funds in year t
N	project lifetime in years
NPV	net present value
P	price per unit of output
PDEBT	proportion of investment financed by borrowing
Q	annual plant capacity
R_t	revenues in year t
r_D	interest rate on borrowed funds
r	discount rate, or cost of capital
T	corporate tax rate
TCC	total capital cost
TCRED	investment tax credit
U	capacity utilization rate
V	annual variable operating costs
WC	working capital
X	minimum [$2,000, 0.2 x FCC]
Y_t	net cash flow in year t
Z_i	percentage that each source of capital i is of total capital

line method of depreciation is used. The salvage value of the facility is assumed to be zero, so the annual depreciation expense is simply given by (FCC - X)/N, where N is the lifetime of the project and X is $2,000 or 20 percent of the fixed capital costs, whichever is less.

The net cash flows represented by equation 8-2 occur at the end of the first through the Nth years. Additional cash inflows occur at the end of the first and Nth year. The additional cash inflow at the end of the first year is the tax savings attributable to the additional first year depreciation deduction of 20 percent of the fixed capital cost or $2,000, whichever is less. By law, the basis for calculating normal depreciation allowances must be reduced by the amount of the additional first year depreciation.[29] The additional cash inflow at the end of the Nth year occurs when the working capital, initially treated as a cash outflow, is recovered.

Because these cash flows occur over a future period of time, they must be discounted by an appropriate interest rate to reflect the fact that a sum of money received at some future date is worth less than an equal sum received today. This discount factor, DF_t, can be given by:

$$DF_t = (1 + r)^{-t} \qquad t = 0, 1, \ldots, N \qquad (8\text{-}5)$$

The sum of the discounted cash flows from a project is called the net present value of that project. That is,

$$NPV = \sum_{t=1}^{N} (Y_t \cdot DF_t) - Y_0 \text{ or} \qquad (8\text{-}6)$$

$$NPV = \sum_{t=1}^{N} [Y_t (1 + r)^{-t}] - Y_0$$

The decision criterion, if funds are available, is to invest in the project if it has a positive NPV at a discount rate equal to the weighted average cost of capital.

To employ this methodology requires the estimation of the weighted average cost of capital to the firm, or more generally, to a group of firms operating in the same industry. RTI calculated the weighted average cost of capital for firms in the metal beverage container industry by employing a methodology where:

$$\text{WACC} = Z_1 K_1 + Z_2 K_2 + Z_3 K_3 \qquad (8\text{-}7)$$

in which WACC is defined as the weighted average cost of capital, Z_i is the percentage that each source of capital is of the total ($\Sigma Z_i = 1.0$), and K_i is the cost of each capital component. The cost of the capital components are defined as K_1 = the required rate of return on long term debt, K_2 = the required rate of return on preferred stock, and K_3 = the required rate of return on common equity. Incurring long term debt and issuing preferred and capital stock are the usual methods of raising capital employed by a firm.

Data on weights and the required rates of return for the various debt instruments were compiled from the financial statements of metal beverage container producing firms. These financial statements were available in publications such as Moody's Industrial Manual and The Value Line Investment Survey. The result of these calculations was an estimated weighted average cost of capital (discount rate) of 11.8 percent for the beverage can industry.

8.4.2.2 Project Ranking Criterion. The specific application of DCF used in the economic analysis is discussed in this section. What is needed is a criterion for ranking alternative investment projects in terms of profitability. It is assumed that, in the absence of the regulatory alternatives, any firm building a new production facility would invest in the most profitable configuration of that facility. This choice can be compared with the one that would have to be built to comply with the regulatory alternative; this forms the basis for calculating price and rate of return impacts.

Equation 8-6 can be rearranged and used as the ranking criterion. The procedure begins by substituting the expressions for R and E (given by equations 8-3 and 8-4, respectively) in equation 8-2. Next, the expressions for Y_0 in equation 8-1 and Y_t in equation 8-2 are substituted into equation 8-6. NPV in equation 8-6 is then set equal to zero and the unit price, P, is solved for by rearranging the terms in Y_t so that the price is on the left hand side of the equal sign and all other terms are on the right hand side:

$$P = \frac{Z}{DF \cdot (1-T) \cdot Q \cdot U} + \frac{V \cdot U + F + I}{Q \cdot U} \qquad (8\text{-}8)$$

where

$$Z = Y_0 - DSL - WC(1+r)^{-N} - X(1+r)^{-1} \cdot T$$

and all other variables are defined in Table 8-17. The resulting expression for P, called the present worth cost, has two terms. The first, or "capital cost" term is that part of the present worth cost accounted for by the initial capital outlay (adjusted for the tax savings attributable to depreciation, recovery of working capital, etc.) and including the return on the invested capital. The second, or "operating cost" term is a function of the fixed and variable operating costs. Hence, for any configuration, the present worth cost just covers the unit operating costs and yields a rate of return, r, over the project's lifetime on the unrecovered balances of the initial investment. It also represents the cost to the manufacturer of an input to the production of a beverage can, namely, the coating.

For each type of facility, equation 8-8 is used to calculate the present worth cost of the coating from each configuration. The results are then ranked in order of cost, from lowest to highest. The most profitable configuration is the one that can coat a can for the lowest cost.

8.4.2.3 Determining the Impacts of the Regulatory Alternatives. This section describes how the impacts of the regulatory alternatives are estimated using the ranking method discussed in section 8.4.2.2. The estimated impacts are presented in section 8.4.3. Three categories of impacts are estimated: price, return on investment, and incremental capital requirements.

Price impacts are calculated directly from equation 8-8. Given the imputed cost of the coating for each control option, cost increases from the base unit cost of the most profitable line can be calculated. These cost increases are translated into price impacts by dividing them by the price received by the producer for the beverage can.

Whereas price impacts are calculated by assuming that all of the incremental costs associated with a given control option are passed forward to the consumer, return on investment (ROI) impacts are estimated by assuming that the producer absorbs all of the incremental costs, thus lowering the ROI. In this case, the price facing the consumer does not change. For any control option, a discount rate exists that enables the producer to maintain the imputed cost of the coating at its baseline level. The baseline cost is the present worth cost associated with the most profitable line configuration and is determined from the procedure described in section 8.4.2.2.

The baseline present worth cost was calculated from equation 8-8 using a specific value of the discount rate, $\bar{r}$. As mentioned previously, the discount rate employed was that calculated as the weighted-average cost of capital. The calculation of the rate of return impact begins by setting $P = \bar{P}$ in equation 8-8, where $\bar{P}$ is the baseline (lowest) cost and then iteratively solving for the value of r that equates the right hand side of equation 8-8 with $\bar{P}$. This value, say r^*, will always be less than $\bar{r}$, the baseline rate of return. The difference between r^* for each control option and $\bar{r}$ constitutes the rate of return impact.

The incremental capital requirements are calculated from the cost data presented in section 8.2. The additional capital required to meet the standards is used as a partial measure of the financial difficulty firms might face in attempting to conform to the standard. Incremental capital requirements also constitute a barrier for firms entering the beverage can market. The magnitude of the additional capital relative to the baseline capital requirements is a measure of the size of this barrier.

8.4.3 Economic Impacts

This section presents the estimated impacts of Regulatory Alternatives II and III on each of four types of production facilities. For each type, the firm is confronted with a set of configurations, corresponding to the "base case" and the control options, from which it selects the most profitable by applying the ranking methods described in section 8.4.2.2 This choice is compared with the configuration needed to comply with the regulatory alternatives; the resulting impacts (if any) are then estimated using the methods described in section 8.4.2.3.

For ease of reference, the four production facilities and the coating operations involved in each are shown below:

Two-piece aluminum- or steel-can integrated facility

- Exterior base coat
- Lithography/overvarnish
- Interior spray

Three-piece steel-sheet coating

- Exterior base coat
- Interior base coat
- Lithography/overvarnish

Three-piece steel-can forming

- Inside spray

Steel- or aluminum-end coating and forming

- Exterior base coat
- Interior base coat

Because the only distinction between the regulatory alternatives involves the use of no-varnish inks or a UV cure for the lithography/overvarnish step under Regulatory Alternative III, the impacts on the three-piece can forming and steel end coating facilities would be identical under both regulatory alternatives. It should also be noted that the control options that satisfy Regulatory Alternative III would also satisfy Regulatory Alternative II. That is, a firm may choose control options satisfying Regulatory Alternative III to meet the standards of Regulatory Alternative II.

Table 8-18 presents the capital and operating costs for small-scale (400 million cans per year) and large-scale (2,400 million cans per year) two-piece aluminium or steel can integrated facilities. The costs are based on those given in section 8.2 and are reproduced here to illustrate the form in which they were used for the analysis. The "annual operating costs" reported in section 8.2 for the base case and each control option are here disaggregated into "fixed" and "variable" costs. Table 8-19 and Table 8-20 show the costs for three-piece sheet coating facilities and three-piece can forming facilities, respectively. Costs are estimated for small (400 million cans per year) and large (800 million cans per year) plants in each case. Table 8-21 supplies cost data for steel- and aluminum-end coating facilities; only one plant size is considered (1,100 million ends per year). Note that the estimated costs are not annualized costs,

TABLE 8-18. COST DATA FOR TWO-PIECE ALUMINUM OR STEEL INTEGRATED FACILITIES

	Small scale [a]			Large scale [b]		
	Installed capital cost[c]	Operating cost (10^3 \$/year)		Installed capital cost[c]	Operating cost (10^3 \$/year)	
Control option	(10^3 \$)	Fixed[d]	Variable[e]	(10^3 \$)	Fixed[d]	Variable[e]
Base case	4,560.0	182.4	1,533.6	14,050.0	562.0	9,988.0
IA	4,765.0	190.6	1,791.4	14,275.0	571.0	12,146.0
IB	3,402.0	136.1	1,604.9	10,188.0	407.5	10,569.5
IC	4,560.0	182.4	1,533.6	14,050.0	562.0	9,988.0
ID	3,202.0	128.1	1,391.9	9,970.0	398.8	8,931.2

[a] Two lines rated at 700 cans/minute operating 4,700 hours per year. Annual production is 400 million cans.

[b] Six lines rated at 800 cans/minute operating 8,400 hours per year. Annual production is 2,400 million cans.

[c] From Table 8-9 in section 8.2.

[d] 4 percent of the capital cost.

[e] Equal to the annual operating cost reported in Table 8-9 minus the fixed cost (see footnote d).

TABLE 8-19. COST DATA FOR THREE-PIECE SHEET COATING FACILITIES

	Small scale[a]			Large scale[b]		
	Installed capital cost[c]	Operating cost (10^3 \$/year)		Installed capital cost[c]	Operating cost (10^3 \$/year)	
Control option	(10^3 \$)	Fixed[d]	Variable[e]	(10^3 \$)	Fixed[d]	Variable[e]
Base case	2,830.0	113.2	892.8	5,660.0	226.4	1,738.6
IIA	3,027.0	121.1	899.9	5,870.0	234.8	1,814.2
IIB	2,739.0	109.6	824.4	5,298.0	211.9	1,622.1
IIC	2,830.0	113.2	892.8	5,660.0	226.4	738.6
IID	2,549.0	102.0	793.0	5,098.0	203.9	549.1

[a] One line at 90 sheets/minute operating 4,240 hours/year split between exterior and interior coating; one line at 90 sheets/minute operating 2,120 hours/year for lithography/overvarnish. Annual production equivalent to 400 million cans.

[b] Two lines at 110 sheets/minute operating 3,460 hours/year split between exterior and interior coating; two lines at 90 sheets/minute operating 2,120 hours/year for lithography/overvarnish. Annual production equivalent to 800 million cans.

[c] From Table 8-10 in section 8.2.

[d] 4 percent of the capital cost.

[e] Equal to the annual operating cost reported in Table 8-10 minus the fixed cost (see footnote d).

TABLE 8-20. COST DATA FOR THREE-PIECE CAN FORMING FACILITIES-INSIDE SPRAY

	Small scale[a]			Large scale[b]		
	Installed capital cost[c]	Operating cost (10^3 \$/year)		Installed capital cost[c]	Operating cost (10^3 \$/year)	
Control option	(10^3 \$)	Fixed[d]	Variable[e]	(10^3 \$)	Fixed[d]	Variable[e]
Base case	1,580.0	63.2	499.8	2,100.0	84.0	901.0
IIIA	1,766.0	70.6	543.4	2,300.0	92.0	1,105.0
IIIB	1,580.0	63.2	449.8	2,100.0	84.0	901.0

[a] One line at 2,160 cans/minute operating 3,090 hours/year. Annual production is 400 million cans.

[b] Two lines at 1,080 cans/minute operating for 4,120 hours/year. Annual production is 800 million cans.

[c] From Table 8-11 in section 8.2.

[d] 4 percent of the capital cost.

[e] Equal to annual operating cost reported in Table 8-11 minus the fixed cost (see footnote d).

TABLE 8-21. COST DATA FOR STEEL- AND ALUMINUM-END SHEET COATING FACILITIES[a]

Control Option	Installed capital cost[b] (10^3 \$)	Operating cost (10^3 \$/year)	
		Fixed[c]	Variable[d]
Base case	1,415.0	56.6	387.4
IVA	1,595.0	63.8	403.4
IVB	1,415.0	56.6	387.4

[a] The facility consists of one line at 90 sheets/minute operating for 3,080 hours/year split between the exterior and interior coats with an annual production of 1.1 billion ends/year.

[b] From Table 8-12 in section 8.2.

[c] 4 percent of the capital cost.

[d] Equal to the annual operating cost from Table 8-12 minus the fixed cost (see footnote c).

that is, they do not include a "capital recovery" component. This aspect of cost accounting is implicitly handled in the DCF approach.

For each facility these costs were inserted into equation 8-8 to determine the present worth cost of applying a coating under each of the control options. All calculations assumed straight line depreciation of capital equipment, a 100 percent capacity utilization rate, an investment tax credit of 10 percent, a corporate tax rate of 46 percent, and a project life of 10 years. Additionally, the calculated discount rate of 11.8 percent applicable to beverage can manufacturing was employed. Working capital was not estimated for this study.

Table 8-22 presents the unit present-worth cost of coating 1,000 cans associated with each control option for both small- and large-scale two-piece can integrated facilities. For each alternative, the control options are ranked from least expensive to most expensive. Under Alternative II, it is assumed that customer demands dictate that firms are not allowed to eliminate the overvarnish (by using no-varnish inks or a UV curve). Thus, firms can not choose control option IB or ID. Under Alternative III, no-varnish inks or UV-curable overvarnishes are used for lithography/ overvarnish operations. Therefore, firms cannot choose control option IA or IC.

Table 8-23 contains the present worth costs and rankings of these costs for three-piece sheet coating facilities. Constraints on the control options available to the firms under each of the two alternatives are as indicated above.

Present worth costs and rankings for three-piece can forming facilities and for steel and aluminum-end sheet coating facilities are presented in Table 8-24 and Table 8-25, respectively. Neither of these two types of facilities perform lithography/overvarnish operations; therefore only two control options exist for these firms. Regulatory Alternatives II and III are identical as applicable to these firms.

The impacts of Regulatory Alternatives II and III are based on the present worth costs and rankings presented in Tables 8-22 through 8-25. Section 8.4.3.1 gives the estimated impacts on two-piece aluminum or steel can integrated facilities. The remaining sections present the impact estimates for three-piece sheet coating facilities (section 8.4.3.2),

TABLE 8-22. PRESENT WORTH COSTS AND RANKINGS FOR TWO-PIECE STEEL OR ALUMINUM INTEGRATED FACILITIES

	Small scale			Large scale		
		Rank[b]			Rank[b]	
Control option	Cost[a] ($/1,000 cans)	Alternative II	Alternative III	Cost[a] ($/1,000 cans)	Alternative II	Alternative III
Base case	6.654	1	3	5.610	1	3
IA	7.425	2	N/A	6.532	2	N/A
IB	6.116	N/A	2	5.454	N/A	2
IC	6.654	1	N/A	5.610	1	N/A
ID	5.460	N/A	1	4.749	N/A	1

[a] All cost calculations were made assuming straight line depreciation of capital equipment, an investment tax credit = 10 percent, a corporate tax rate = 46 percent, a project life = 10 years, and a discount rate = 11.8 percent. Working capital was not estimated for this study.

[b] Costs were ranked from lowest (rank = 1) to highest.

N/A signifies that the control option is not applicable to the regulatory alternative under consideration.

TABLE 8-23. PRESENT WORTH COSTS AND RANKINGS FOR THREE-PIECE SHEET COATING FACILITIES

Control option	Small scale			Large scale		
	Cost[a] ($/1,000 cans)	Rankb		Cost[a] ($/1,000 cans)	Rank[b]	
		Alternative II	Alternative III		Alternative II	Alternative III
Base case	3.982	1	3	3.923	2	3
IIA	4.122	2	N/A	4.083	3	N/A
IIB	3.755	N/A	2	3.716	N/A	2
IIC	3.982	1	N/A	2.673	1	N/A
IID	3.559	N/A	1	2.263	N/A	1

[a] All cost calculations were made assuming straight line depreciation of capital equipment, an investment tax credit = 10 percent, a corporate tax rate = 46 percent, a project life = 10 years, and a discount rate = 11.8 percent. Working capital was not estimated for this study.

[b] Costs were ranked from lowest (rank = 1) to highest.

N/A signifies that the control option is not applicable to the regulatory alternative under consideration.

TABLE 8-24. PRESENT WORTH COSTS AND RANKINGS FOR THREE-PIECE CAN FORMING FACILITIES-INSIDE SPRAY[a]

Control option	Small scale		Large scale	
	Cost[a] ($/1,000 cans)	Rank[b]	Cost[a] ($/1,000 cans)	Rank[b]
Base case	2.226	2	1.776	1
IIIA	2.450	3	2.092	2
IIIB	2.101	1	1.776	1

[a] All cost calculations assumed straight line depreciation of capital equipment, an investment tax credit = 10 percent, a corporate tax rate = 46 percent, a project life = 10 years, and a discount rate = 11.8 percent. Working capital was not estimated for this study.

[b] Costs were ranked from lowest (rank = 1) to highest.

TABLE 8-25. PRESENT WORTH COSTS AND RANKINGS FOR STEEL- AND ALUMINUM-END SHEET COATING FACILITIES

Control option	Cost[a] ($/1,000 cans)	Rank[b]
Base case	0.670	1
IVA	0.725	2
IVB	0.670	1

[a] All cost calculations assumed straight line depreciation of capital equipment, an investment tax credit = 10 percent, a corporate tax rate = 46 percent, a project life = 10 years, and a discount rate = 11.8 percent. Working capital was not estimated for this study.

[b] Costs were ranked from lowest (rank = 1) to highest.

three-piece can forming facilities (section 8.4.3.3), and steel- and aluminum-end coating facilities (section 8.4.3.4).

8.4.3.1 Impacts on Two-Piece Facilities. Table 8-26 shows the price impacts of the regulatory alternatives by control option for small-scale and large-scale facilities. The return on investment (ROI) impacts and the incremental capital requirements are presented in Tables 8-27 and 8-28 respectively.

Under Regulatory Alternative II, the best available waterborne coating (control option C) allows the firm a chance for compliance at no additional cost. The incineration option (control option A) would cause the small-scale firm to experience a price impact of 1.5 percent, a negative ROI impact of 5.7 percentage points, and an increase in capital requirements of 4.5 percent. Ostensibly, the large-scale firm would not consider the incineration option as there is no positive rate of return associated with this option.

Regulatory Alternative III would have no economic impact on small or large two-piece facilities. The base case (CTG waterborne coatings) is the least profitable technique; thus, firms have an economic incentive to adopt one of the control options, even in the absence of a regulation.

8.4.3.2 Impacts on Sheet-Coating Facilities. Price impacts, ROI impacts, and incremental capital outlay requirements are given in Tables 8-29, 8-30, and 8-31, respectively.

Under Regulatory Alternative II, firms are indifferent between using the best available waterborne coatings (option C) and CTG waterborne coatings (base case). There would thus be no impact on firms using option C under Regulatory Alternative II. The incineration strategy (option A) under this alternative would result in price impacts of 0.2 to 0.3 percent, negative ROI impacts of 1.6 to 1.8 percentage points (assuming costs are absorbed by the firms), and additional capital requirements of 5.5 to 7.0 percent.

Neither of the two options available to comply with Regulatory Alternative III would have associated price, ROI, or capital requirements impacts as the present worth coating costs of both control options are less than those associated with the base case.

TABLE 8-26. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON TWO-PIECE ALUMINUM OR STEEL INTEGRATED FACILITIES (%)[a]

Control option	Small scale		Large scale	
	Alternative II	Alternative III	Alternative II	Alternative III
IA	1.54	N/A	1.84	N/A
IB	N/A	0.00	N/A	0.00
IC	0.00	N/A	0.00	N/A
ID	N/A	0.00	N/A	0.00

[a] A baseline price of $50 per 1,000 cans was used to calculate the impacts. The unit present worth costs and rankings from Table 8-22 were used to determine the cost increases, which were then translated into price increases by dividing them by $50. The "base case" unit cost was assumed to be incorporated in the $50 base price for 1,000 cans. Thus, increases over this "base case" cost due to the control options would generate the price increases reported in the table. If the unit coating cost of a control option was less than the "base case" cost, then there is no impact and the table entry will read "0.00."

TABLE 8-27. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON TWO-PIECE ALUMINUM OR STEEL INTEGRATED FACILITIES[a]

Control option	Small scale		Large scale	
	Alternative II	Alternative III	Alternative II	Alternative III
IA	-5.67	N/A	---[b]	N/A
IB	N/A	0.00	N/A	0.00
IC	0.00	N/A	0.00	N/A
ID	N/A	0.00	N/A	0.00

[a] Baseline ROI = 11.8 percent.

[b] No positive rate of return exists for this control option.

TABLE 8-28. INCREMENTAL CAPITAL REQUIREMENTS OF REGULATORY ALTERNATIVES FOR TWO-PIECE ALUMINUM OR STEEL INTEGRATED FACILITIES (10^3 \$)[a]

Control option	Smale scale		Large scale	
	Alternative II	Alternative III	Alternative II	Alternative III
IA	205.0 (4.5)[b]	N/A	225.0 (1.6)[b]	N/A
IB	N/A	0.00	N/A	0.00
IC	0.00	N/A	0.00	N/A
ID	N/A	0.00	N/A	0.00

[a] Calculated from Table 8-18.

[b] Percentage change from the "base case" amount.

N/A signifies that the control option is not applicable to the regulatory alternative under consideration.

TABLE 8-29. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON THREE-PIECE SHEET COATING FACILITIES (%)[a]

Control option	Small scale		Large scale	
	Alternative II	Alternative III	Alternative II	Alternative III
IIA	0.23	N/A	0.27	N/A
IIB	N/A	0.00	N/A	0.00
IIC	0.00	N/A	0.00	N/A
IID	N/A	0.00	N/A	0.00

[a] A baseline price of $60 per 1,000 cans was used to calculate the impacts. The unit present worth costs and rankings from Table 8-23 were used to determine the cost increases, which were then translated into price increases by dividing them by $60. The "base case" unit cost was assumed to be incorporated in the $60 base price for 1,000 cans. Thus, increases over this "base case" cost due to the control options would generate the price increases reported in the table. If the unit coating cost of a control option was less than the "base case" cost, then there is no impact and the table entry will read "0.00."

TABLE 8-30. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON THREE-PIECE SHEET COATING FACILITIES[a]

Control option	Small scale		Large scale	
	Alternative II	Alternative III	Alternative II	Alternative III
IIA	-1.55	N/A	-1.84	N/A
IIB	N/A	0.00	N/A	0.00
IIC	0.00	N/A	0.00	N/A
IID	N/A	0.00	N/A	0.00

[a] Baseline ROI = 11.8 percent.

TABLE 8-31. INCREMENTAL CAPITAL REQUIREMENTS OF REGULATORY ALTERNATIVES FOR THREE-PIECE SHEET COATING FACILITIES (10^3 \$)[a]

Control option	Small scale		Large scale	
	Alternative II	Alternative III	Alternative II	Alternative III
IIA	197.0 (7.0)[b]	N/A	310.0 (5.5)[b]	N/A
IIB	N/A	0.00	N/A	0.00
IIC	0.00	N/A	0.00	N/A
IID	N/A	0.00	N/A	0.00

[a] Calculated from Table 8-19.

[b] Percentage change from "base case" amount.

N/A signifies that the control option is not applicable to the regulatory alternative under consideration.

8.4.3.3 Impacts on Can Forming Facilities. Price impacts, ROI impacts, and incremental capital outlay requirements are presented in Tables 8-32, 8-33, and 8-34, respectively.

Under Regulatory Alternative II, large-scale firms are indifferent between the best available waterborne coatings (control option B) and CTG waterborne coatings (base case) since the costs are identical. Small-scale firms would have an economic incentive to adopt control option B as the unit present worth coating cost is slightly less. Thus, no impacts arise from adoption of this control option. Large firms would ostensibly adopt control option B even without regulatory action.

The incineration option (control option A) implies a price impact of 0.4 percent for small firms, and 0.5 percent for large firms. Small firms would suffer a decline in ROI of 4.4 percentage points; large firms would suffer a decline of 10.1 percentage points. Capital requirements would increase by 11.8 percent for small firms and by 9.5 percent for large firms.

8.4.3.4 Impacts on Steel- and Aluminum-End Sheet Coating Facilities. Price impacts, ROI impacts, and incremental capital requirements are given in Tables 8-35, 8-36, and 8-37, respectively.

Firms are indifferent between the best available (option B) and CTG (base case) waterborne coatings. Thus, no economic impacts are associated with this control option.

The incineration option would result in price increases of 0.1 percent, a decline in ROI of 3.2 percentage points, and incremental capital requirements of 12.7 percent.

8.5 POTENTIAL SOCIOECONOMIC AND INFLATIONARY IMPACTS

Executive Order 12044 requires that the inflationary impacts of major legislative proposals, regulations, and rules be evaluated. The regulatory alternatives would be considered a major action (thus requiring the preparation of an Inflation Impact Statement) if either of the following criteria apply:

1. Additional annualized costs of compliance, including capital charges (interest and depreciation), will total $100 million within any calendar year by the attainment date, if applicable, or within five years of implementation.

TABLE 8-32. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON THREE-PIECE CAN FORMING FACILITIES (%)[a]

Control option	Small scale	Large scale
IIIA	0.37	0.53
IIIB	0.00	0.00

[a] A baseline price of $60 per 1,000 cans was used to calculate the impacts. The unit present worth costs and rankings from Table 8-24 were used to determine the cost increases, which were then translated into price increases by dividing them by $60. The "base case" unit cost was assumed to be incorporated in the $60 base price for 1,000 cans. Thus, increases over this "base case" cost due to the control options would generate the price increases reported in the table. If the unit coating cost of a control option was less than the "base case" cost, then there is not impact and the table entry will read "0.00."

TABLE 8-33. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON THREE-PIECE CAN FORMING FACILITIES[a]

Control option	Small scale	Large scale
IIIA	-4.39	-10.13
IIIB	0.00	0.00

[a] Baseline ROI = 11.8 percent.

TABLE 8-34. INCREMENTAL CAPITAL REQUIREMENTS OF REGULATORY ALTERNATIVES FOR THREE-PIECE CAN FORMING FACILITIES (10^3 \$)[a]

Control option	Small scale	Large scale
IIIA	186.0 (11.8)	200.0 (9.5)[b]
IIIB	0.0	0.0

[a] Calculated from Table 8-20.

[b] Percentage increase from the "base case" amount.

TABLE 8-35. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON STEEL- AND ALUMINUM-END SHEET COATING FACILITIES (%)[a]

Control option	Impact
IVA	0.09
IVB	0.00

[a] A baseline price of $60 per 1,000 cans was used to calculate the impacts. The unit present worth costs and rankings from Table 8-25 were used to determine the cost increases, which were then translated into price increases by dividing them by $60. The "base case" unit cost was assumed to be incorporated in the $60 base price for 1,000 cans. Thus, increases over this "base case" cost due to the control options would generate the price increases reported in the table. If the unit coating cost of a control option was less than the "base case" cost, then there is no impact and the table entry will read "0.00."

TABLE 8-36. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON STEEL- AND ALUMINUM-END SHEET COATING FACILITIES[a]

Control option	Change in ROI
IVA	-3.24
IVB	0.00

[a] Baseline ROI = 11.8 percent.

TABLE 8-37. INCREMENTAL CAPITAL REQUIREMENTS OF REGULATORY ALTERNATIVES ON STEEL- AND ALUMINUM-END SHEET COATING FACILITIES (10^3 $)[a]

Control option	Impact
IVA	180.0 (12.7)[b]
IVB	0.0

[a] Calculated from Table 8-21.

[b] Percentage increase from the "base case" amount.

2. Total additional cost of production is more than 5 percent of the selling price of the product.

8.5.1 Annualized Cost Criterion

To estimate the incremental annualized cost of compliance with the regulatory alternatives, the increase in can production between 1980 and 1985 that could be attributed to new sources needed to be determined. This was done by increasing estimated production in 1979, 65 billion cans, at a compounded annual growth rate of 5.5 percent (see section 8.1.). All of the difference between 1985 production of 89.6 billion cans and 1980 production of 68.6 billion, or 21 billion cans. In addition, if the actual life of a facility is assumed to be 10 years, then 10 percent must be replaced each year by lines that will be subject to NSPS regulations. Therefore, taking 10 percent of the 1980 production of 68.6 billion cans (over the five year interval) will yield an additional 34 billion cans. Total production over the next five years that will be subject to NSPS regulations is therefore 55 billion cans.

It was further assumed that all new sources would be one of four types: (1) small three-piece facilities, (2) large scale three-piece, (3) small-scale two-piece, and (4) large-scale two-piece facilities. For each type of facility, the projected increase in output was translated into "model plant equivalents" by dividing it by the capacity of the facility (400 million for small scale facilities, 800 million for a large three-piece plant, and 2,400 million for a large two-piece plant). A small three-piece plant consisted of one small sheet coating, one small can forming, and 0.364 end coating facility. A large three-piece plant consisted of one large sheet coating, one large can forming, and 0.727 end coating facility.

The option that had the greatest impact described in section 8.4.3 was chosen to test for compliance with the annualized cost criterion, to generate "worst case" results. For all facilities, this was the incineration option A. The annualized cost of this option was determined by multiplying a capital recovery factor of 0.1755 (which assumes a discount rate of 11.8 percent and a depreciation period of 10 years) by the installed capital cost reported in Tables 8-18 through 8-21 and adding this figure to the sum of the fixed and variable costs. The annualized cost of the "base case" was similarly determined; the difference between these two costs is the incremental annualized cost attributable to the control option. This was multiplied by the appropriate number of "model plant equivalents" for each production facility, which were then combined into the four plant size and type classifications described above. All results are given in Table 8-38.

As the table shows, the maximum impact would be $51 million (large-scale two-piece), well under the $100 million threshold. In actuality, the incremental cost of compliance would be much closer to zero, since the regulatory alternatives would have no impact (see 8.4.3.1). Thus, the regulatory alternatives do not qualify as a major action by this criterion.

8.5.2 Product Price Criterion

To determine if the price of a three-piece can would rise by 5 percent or more because of the regulatory alternatives, the maximum price impacts from Table 8-29 (small- and large-scale sheet-coating facilities), Table 8-32 (can-forming facilities), and Table 8-35 (end-coating facilities) were summed. Regulatory Alternative II would force small scale facilities to raise prices by 0.7 percent and large scale facilities by 0.9 percent. Under Regulatory Alternative III, the price increases would be 0.5 and 0.6 percent for small and large scale facilities, respectively. Alternative III has no impact, so the price increase would be zero percent.

For two-piece can facilities, under Regulatory Alternative II, the largest impact for small scale firms was 1.5 percent and for large scale firms, 1.8 percent. Alternative III has no impact, so the price increase would be zero percent.

The price increases under both alternatives for three- and two-piece facilities are well under the 5 percent threshold. Therefore, neither alternative qualifies as a major action.

TABLE 8-38. INCREMENTAL ANNUALIZED COST OF COMPLIANCE WITH REGULATORY ALTERNATIVES, 1985[a]

All incremental production from	Model plant equivalents	Control option	Incremental cost (10^3 $)
I. Small three-piece			
Sheet coating	138	IIA	6,900
Can forming	138	IIIA	11,592
Steel ends	50	IVA	2,750
			21,242[b]
II. Large three-piece			
Sheet coating	69	IIA	8,349
Can forming	69	IIIA	17,043
Steel ends	50	IVA	2,750
			28,142[b]
III. Small two-piece plants	138	IA	41,676[b]
IV. Large two-piece plants	23	IA	50,738[b]

[a] The incremental annualized cost is equal to the sum of the incremental operating cost and the incremental annualized capital cost. All cost data are from Tables 8-18, 8-19, 8-20, and 8-21. To calculate the incremental annualized capital cost the incremental capital investment was multiplied by a capital recovery factor of 0.1755 which is based on an interest rate of 11.8 percent and a depreciation period of 10 years.

[b] Total incremental annualized cost of compliance.

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APPENDIX A

EVOLUTION OF THE BACKGROUND DOCUMENT

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EVOLUTION OF THE BACKGROUND DOCUMENT

This study to develop proposed standards of performance for beverage can surface coating operations began in September 1978 with Springborn Laboratories, Inc., initiating the development of background information. In May 1979 responsibility for preparation of the Background Information Document (BID) was assigned to the Research Triangle Institute. Major events since RTI was assigned responsibility are shown in Table A-1.

Initial RTI activities included a review of preliminary drafts of the Springborn SSEIS and the preparation of the Phase II and III Work Plan. In June 1979, the Air Pollution Technical Information Center conducted a literature search on the beverage can surface coating industry. Project personnel reviewed this information during the next month and selected specific literature items for further study and analysis.

Prior to RTI's assumption of responsibility for preparation of the BID, EPA's Emission Monitoring Branch prepared an emission test plan that involved testing of a three-piece beverage can facility using solvent-borne coatings without an emission control system and a two-piece beverage can facility using solvent-borne coatings with incineration. The emission test at the three-piece can plant, scheduled in July, was aborted because of fire damages to the test equipment. This test as well as the emission test of the two-piece can plant were performed in October by the Research Corporation of New England (TRC) in cooperation with RTI. The test of the three-piece plant was only partially successful because of loss in shipment of the coating samples to the laboratory. The test of the two-piece plant was successful. However, results were not available for inclusion in the draft BID because of delays in the laboratory analysis of the gas sampler.

In May 1979 the RTI project team met with Springborn Laboratories to coordinate transfer of responsibility. Also during May a meeting was held with officials of Midland-Ross Corporation, a vendor of coating cure ovens and emission control systems.

From May 1979 to date, numerous telephone contacts were made with coating suppliers, equipment vendors, and beverage can surface coaters to obtain information on the coating processes, equipment, coating formulations, and emission control systems.

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TABLE A-1. MAJOR EVENTS AND ACCOMPLISHMENTS IN THE EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

Month	Event
September 1978	Work begun by Springborn Laboratories, Inc. to develop a Standard Support and Environmental Impact Statement (SSEIS) document.
April 1979	Plant visit made by Research Triangle Institute (RTI) to Joseph Schlitz Brewing Company, Container Division, Winston-Salem, NC.
May 1979	Work begun by RTI. Meeting held with Springborn Laboratories, Inc., to coordinate transfer of responsibility for preparation of the BID.
June 1979	Phase II and Phase III Work Plan completed.
June 1979	Visit to Forest Park plant, American Can Company, Atlanta, GA.
July 1979	Visit to Metal Container Corporation (Anheuser-Busch), Jacksonville, FL
August 1979	Phase II and Phase III Work Plan revised.
August 1979	Preliminary model plants and regulatory alternatives defined.
September 1979	Final model plants and regulatory alternatives defined.
October 1979	Technical background BID chapter completed.
October 1979	Emission tests conducted at American Can Company plant, Atlanta, GA, and Metal Container Corporation plant, Jacksonville, FL.
November 1979	Tabular cost data developed.
December 1979	Cost study completed.
January 1980	Technical background distributed for external review.
January 1980	Preliminary economic analysis completed.
February 1980	Final economic analysis completed.
February 1980	Working Group packages distributed.
March 1980	Draft BID approved by Working Group
April 1980	NAPCTAC/Steering Committee packages completed.
April 1980	Visit to Miller Plant, Reidsville, NC.
May 1980	NAPCTAC/Steering Committee packages distributed.
June 1980	Draft BID reviewed by NAPCTAC.
July 1980	Draft BID approved by Steering Committee.

The technical background chapters describing the industry, emission control techniques, reconstruction and modification considerations, model plants, and regulatory alternatives were completed in December 1979 and mailed to industry for review and comment. The preliminary economic analysis was completed in January 1980 and the final economic analysis in February.

Industry comments on the draft BID were analyzed and incorporated into a revised version that was sent to Working Group in February 1980. Working Group comments as well as delayed industry comments were considered and incorporated into the present version of the BID along with the proposed standards and preamble to complete the package that was distributed to NAPCTAC members in May 1980. Similar packages were sent to industry and environmental groups.

NAPCTAC review was accomplished in June and the proposal package submitted for Steering Committee review and AA concurrence in July.

APPENDIX B

INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

Table B-1 lists the locations in this document of certain information pertaining to environmental impact, as outlined in Agency Guidelines (39 FR 37419, October 21, 1974).

TABLE B-1. LOCATIONS OF INFORMATION CONCERNING ENVIRONMENTAL IMPACT WITHIN THE BACKGROUND INFORMATION DOCUMENT

Agency guidelines for preparing regulatory action environmental impact statements (39 FR 37419, October 21, 1974)	Location within the Background Information Document
Background and summary of regulatory alternatives	Chapter 6, Section 6.3
Statutory basis for proposing standards	Chapter 2, Section 2.1
Relationships to other regulatory agency actions	Chapters 3, 7, and 8
Industry affected by the regulatory alternatives	Chapter 3, Section 3.1, and Chapter 8, Section 8.1
Specific processes affected by the regulatory alternatives	Chapter 3, Section 3.2.

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APPENDIX C
DATA ON LOW-SOLVENT WATERBORNE COATINGS

APPENDIX C

DATA ON LOW-SOLVENT WATERBORNE COATINGS

C.1 INTRODUCTION

Data on low-solvent waterborne coatings currently in use or being marketed by coating suppliers are presented in this appendix. It should be noted that the coatings included in this appendix represent the lower VOC content coatings being used by some coaters rather than representing the range of coatings used throughout the beverage can surface coating industry. The data presented here consolidate and summarize coating information.

C.2 LOW-SOLVENT WATER-BASED COATINGS

C.2.1 Exterior Base Coat

Low VOC content coatings being used for exterior base coating for two-piece cans and three-piece sheets range from 0.23 to 0.36 kilogram of VOC per litre of coating solids. Identification and current status are shown in Table C-1.

C.2.2 Overvarnish

Low VOC content coatings used for overvarnish for two-piece cans and three-piece sheets, and for exterior coating for steel- and aluminum-end sheets, range from 0.33 to 0.50 kilogram of VOC per litre of coating solids. Identification and current status are shown in Table C-2.

C.2.3 Inside Spray, Two-Piece Cans

Low VOC content coatings used for inside spray for two-piece cans range from 0.83 to 0.95 kilogram of VOC per litre of coating solids. Identification and current status are shown in Table C-3.

C.2.4 Inside Spray, Three-Piece Cans

Low VOC coatings used for inside spray for three-piece steel cans range from 0.58 to 0.64 kilogram of VOC per litre of coating solids. Identification and current status are shown in Table C-4.

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TABLE C-1. LOW-SOLVENT WATERBORNE COATINGS: TWO-PIECE CANS EXTERIOR BASE COAT

Coating	Current status	VOC content		kg/litre[a] solids
		lb/gal less H_2O	kg/litre less H_2O	
Not specified	Typical coating used by Reynolds on new and existing lines[1]	1.50	0.18	0.23
Midland-Dexter 1401	Planned for new lines by Reynolds[2]	1.50	0.18	0.23
Inmont S21-119B[b]	Considered by Metal Container Corporation for converting to waterborne[3]	2.09	0.25	0.36
Inmont S21-121A	Available commercially[4]	1.81	0.22	0.29[c]
Whittaker 102W33	Commercially available for two-piece steel cans	2.1	0.25	0.36

[a] Calculated using VOC density of 0.85 kg/litre.

[b] Clear base coat.

[c] Calculated from formulation data.

TABLE C-2. LOW-SOLVENT WATERBORNE COATINGS: TWO-PIECE CANS AND THREE-PIECE SHEET OVERVARNISH

Coating	Current status	VOC content		
		lb/gal less H_2O	kg/litre less H_2O	kg/litre[a] solids
Not specified	Typical coating used by Reynolds on new and existing lines[1]	2.00	0.24	0.34
PPG CC 3180D	Planned for new lines by Reynolds[2]	2.06	0.25	0.35
Inmont S145-124	Planned for new lines by Reynolds[2]	2.06	0.25	0.35
Inmont S12-121	Commercially available[5]	2.47	0.30	0.46
Mobil 9536-005	Commercially available for some uses[6]	2.60	0.32	0.50
PPG-CE 3180D	Used at Miller's Reidsville plant[7]	1.96	0.24	0.33
Whittaker 62C10A	Commercially available for two-piece steel and aluminum cans	2.16	0.26	0.38
Whittaker 62C10-3	Commercially available for two-piece aluminum cans	1.62	0.20	0.26

[a] Calculated using VOC density of 0.85 kg/litre.

TABLE C-3. LOW-SOLVENT WATERBORNE COATINGS: TWO-PIECE CAN INSIDE SPRAY

Coating	Current status	VOC content lb/gal less H_2O	VOC content kg/litre less H_2O	kg/litre[a] solids
DuPont RK-Y-6077	Commercially available[8] [9]	3.57	0.434	0.89
Glidden 62-640C-549A	Commercially available[10] Planned for new lines by Reynolds[2] In use at Miller's Reidsville plant	3.58 b	0.435	0.89
Not specified	Typical coating used by Reynolds in new and existing lines[1]	3.50	0.42	0.83
Midland 4000W13M	Commercially available for aluminum beer cans[12] Under qualification by National Can[11]	3.70 c	0.45	0.85
Midland 4000W22M	Considered by Metal Container Corporation for conversion to waterborne[3]	3.60	0.44	0.90

[a] Calculated using VOC density of 0.85 kg/litre.

[b] Miller reports VOC content of 3.8 lb/gal, less water.

[c] National Can reports VOC content of 3.4 lb/gal, less water.

TABLE C-4. LOW-SOLVENT WATERBORNE COATINGS: THREE-PIECE CAN INSIDE SPRAY

Coating	Current status	VOC content		kg/litre[a] solids
		lb/gal less H_2O	kg/litre less H_2O	
PPG CS625-2	Under qualification by National Can[11]	3.00	0.36	0.64
Mobil 78W263	Under consideration by National Can[11] for inclusion in qualification program	2.93	0.36	0.61
Midland CR4-374	Under consideration by National Can[11] for inclusion in qualification program	2.85	0.35	0.58

[a] Calculated using VOC density of 0.85 kg/litre.

C.2.5 Interior Base Coat, Three-Piece Cans

Low VOC content coatings used for interior base coating for three-piece sheets and interior coating for aluminum- and steel-end sheets range from 0.50 to 0.53 kilogram of VOC per litre of coating solids. Identification and current status are shown in Table C-5.

C.2.6 Exterior Coat, Three-Piece Cans

Low VOC content coatings used for exterior base coating for three-piece sheets contain 0.50 kilogram of VOC per litre of coating solids. Identification and current status are shown in Table C-6.

C.2.7 Exterior Coat, Steel- and Aluminum-End Stock

Low VOC content coatings used for exterior coatings for steel and aluminum sheets for end stock range from 0.48 to 0.52 kilogram of VOC per litre of coating solids. Identification and current status are shown in Table C-7.

C.2.8 Interior Coat, Steel- and Aluminum-End Stock

Low VOC content coatings used for interior coating for steel and aluminum sheets for end stock range from 0.48 to 0.52 kilogram of VOC per litre of coating solids. Identification and current status are shown in Table C-8.

TABLE C-5. LOW-SOLVENT WATERBORNE COATINGS: THREE-PIECE SHEET INTERIOR BASE COAT

Coating	Current status	VOC content		
		lb/gal less H_2O	kg/litre less H_2O	kg/litre[a] solids
PPG CS 3038-1	Under qualification by National Can[13]	2.68[b]	0.33	0.53
Mobil S-9536-004	Commercially available[6] Currently in use by National Can[13]	2.60 b	0.32	0.50
Mobil 79W195A	Under development[6] Under qualification by National Can[13]	2.70	0.33	0.53

[a] Calculated using VOC density of 0.85 kg/litre.

[b] National Can reports a VOC content of 2.86 lb/gal, less water.

TABLE C-6. LOW-SOLVENT WATERBORNE COATINGS: EXTERIOR BASE COAT, THREE-PIECE SHEETS

Coating	Current status	VOC content		
		lb/gal less H_2O	kg/litre less H_2O	kg/litre[a] solids
Mobil S-9536-004	Commercially available[6]	2.60	0.32	0.50
Mobil S-9536-006	Commercially available[6]	2.60	0.32	0.50

[a] Calculated using VOC density of 0.85 kg/litre.

TABLE C-7. LOW-SOLVENT WATERBORNE COATING: END STOCK SHEET EXTERIOR COAT

Coating	Current status	VOC content		
		lb/gal less H_2O	kg/litre less H_2O	kg/litre[a] solids
Mobil S-9536-005	Commercially available[6] Currently in use by National Can[13]	2.60 b	0.32	0.50
Celanese X1755	Under qualification by National Can[13]	2.66[b]	0.32	0.52
Inmont W131-13	Under qualification by National Can[13]	2.51[b]	0.30	0.48

[a] Calculated using VOC density of 0.85 kg/litre.

[b] National Can reports a VOC content of 2.86 lb/gal less water.

TABLE C-8. LOW-SOLVENT WATERBORNE COATINGS: END STACK SHEET INTERIOR COAT

Coating	Current status	VOC content		
		lb/gal less H_2O	kg/litre less H_2O	kg/litre[a] solids
Celanese X1751	Under qualification by National Can[13]	2.66[b]	0.32	0.52
Inmont W131-13	Under qualification by National Can[13]	2.51[b]	0.30	0.48

[a] Calculated using VOC density of 0.85 kg/litre.

[b] VOC content provided by National Can.

C.3 REFERENCES

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APPENDIX D

EMISSION MEASUREMENT AND CONTINUOUS MONITORING

APPENDIX D - EMISSION MEASUREMENT AND CONTINUOUS MONITORING

D.1 EMISSION MEASUREMENT METHODS

During the standard support study for the can coating industry, the U.S. Environmental Protection Agency conducted tests for volatile organic compounds (VOC) at two plants. At one three piece steel can manufacturing plant one set of equipment (line) used to apply and cure the base coat to the sheets of steel was tested. The purpose of this test program was to determine the relative amounts of VOC emitted from various portions of the process line compared to the VOC in the coating used. The specific areas of concern were the application station including the flashoff area prior to the oven and the oven exhaust. The amount of solids applied to the steel sheets was also determined. To reduce variations in the test results due to process variations incurred from using different solvent content coatings, all of the test program was conducted with the same base coat. Since the purpose of the test program was to determine the relative amounts of VOC emitted from the various parts of the line, no attempt was made to assure that this coating represents the 'average' coating used at this plant or in the industry. The coating used, however, represents about 30 percent (by volume) of the total coating used at this plant.

A total of six runs were conducted to determine the average VOC emissions split. Each run consisted of coating approximately 1900 sheets of metal and lasted approximately 30 minutes. During each run a material balance was conducted on the weight of coating (as applied), and roller cleaning (or backwash) solvent. Additionally, thirty individual sheets were preweighed, inserted into the 1900 sheets, coated, cured, and

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then reweighed to obtain an average solids weight gain on the sheets due to the coating process. (As an additional procedure, each of these thirty sheets were also checked using an instrument in use by the company which measures solids weight gain as a function of electrical resistance of the solids thickness.) During each run, stack tests were conducted at the main drying oven exhaust and the cooling zone exhaust. The stack tests included determining (1) the volumetric flow rates at both locations using EPA Reference Methods 1 and 2, (2) the average VOC concentration at both locations using proposed EPA Reference Method 25, "Determination of Total Gaseous Nonmethane Organic Emissions as Carbon (TGNMO)", and (3) the continuous VOC concentration at the main oven exhaust by direct measurement with a flame ionization analyzer calibrated with propane.

At the second plant, a two piece aluminum can manufacturing plant, the equipment used to apply and cure the interior coating (inside spray) to the cans was tested. The purposes of this test program were to determine (1) the relative amounts of VOC emitted from various portions of the process line compared to the total VOC in the coating used and (2) the effectiveness of the enclosed conveyor system in capturing VOC emitted. The specific areas of concern were (1) the application station, (2) the enclosed conveyor system between the application station and the oven, and (3) the oven exhaust. The amount of solids applied to individual cans was also determined for a limited number of cans. Because this plant uses only one type of interior coating, the emission data should be representative of this plant within the limits of accuracy of the data. However, no attempt was made to ascertain the relationship of this coating or plant to the 'average' within the industry.

This plant is a computer controlled plant with four lines (sets of equipment) used to manufacture cans. The test program consisted of performing a material balance of the volume of interior coating used during a test period of 3 to 8 hours each day for 4 days. The number of cans produced to which interior coating was applied was determined by monitoring the individual counters on each interior coating nozzle on all four lines. This provided daily average coating usage per can. Because one line was producing a different size can, the number of cans coated on that line was adjusted by a ratio of surface area coated to surface area of the cans coated on the other lines. Throughout the test program, a total of six stack test runs were completed at the interior spray operation on one of the four production lines to characterize the average VOC emissions split. During each run of approximately 30 minutes, the total number of cans coated on that line was recorded, and the average VOC concentration at three locations was determined using proposed EPA Reference Method 25 and an integrated bag sampling technique analyzed by FIA. Additionally, throughout the test program, volumetric flow rates were determined at these locations and three other locations. The number of cans coated, the volumetric flow rates, and average VOC concentrations were used to obtain average VOC emission rates per can at these various locations. The average VOC Emission rate on a per can basis has been estimated from the company's record of solvent content of the coating and the average coating usage obtained from the material balance. The percentage split of emissions are based on this estimate.

D.2 PERFORMANCE TEST METHODS

Performance test methods are needed to determine the VOC content of the coating and to determine the overall control efficiency of an add-on VOC control system.

D.2.1 Volatile Organic Compound Content of the Coating

The volatile organic content of the coating may be determined by the manufacturer's formulation or from Reference Method 24, "Determination of Volatile Organic Content (as Mass) of Paint, Varnish, Lacquer, or Related Products."

Reference Method 24 combines several ASTM standard methods which determine the volatile matter content, density, volume of solids, and water content of the paint, varnish, lacquer, or related coating. From this information, the mass of volatile organic compounds (VOC) per unit volume of coating solids is calculated. The estimated cost of analysis per coating sample is $150. For aqueous coatings, there is an additional $100 per sample for water content determination. Because the testing equipment is standard laboratory apparatus, no additional purchasing costs are expected.

D.2.2 Control Efficiency of VOC Add-on Control System

If the VOC content of the coatings used exceeds the level of the recommended standard, the efficiency of the add-on control system must be determined. This would be used in conjunction with the VOC content of the coating used to determine compliance with the recommended standard.

For those types of control systems which do not destroy or change the nature of VOC emissions, the recommended procedure is a material balance system where the mass of the VOC recovered by the control system is determined and used in conjunction with the mass of VOC in the coating used over the same period of time. The length of time during which this material balance is conducted will be dependent on the Agency decision on whether to require continual compliance or to demonstrate compliance during an initial performance test. Examples of control systems where this procedure would be applicable are refrigeration and carbon adsorption systems.

For those control systems which alter the VOC emissions (such as incinerators) a different approach is recommended. Ideally, the procedure would directly measure all VOC emitted to the atmosphere. However, this would require measurement of the VOC emissions which escape capture prior to the incinerator (control system) by construction of a complex ducting system and measurement of the VOC emissions exhausting to atmosphere from the control system.

The recommended procedure requires simultaneous measurement of the mass of VOC (as carbon) entering the control system and exiting the control system to the atmosphere. Methods 1, 2, 3, and 4 are recommended to determine the volumetric flow measurements. Reference Method 25 is recommended to determine the VOC (as carbon) concentration. These results are then combined to give the mass of VOC (as carbon) entering the control system and exiting the control system to the atmosphere. The control efficiency of the control system is determined from these data.

The average of three runs should be adequate to characterize the control efficiency of the control system. The length of each run would be dependent on the operational cycle of the control system employed. Minimum sampling time would be in the range of 30 minutes and would be dependent on the size of the evacuated tanks and the sampling rate employed to obtain a sample. The control agency should also consider the representativeness of the solvents and coatings used during the test program. It is assumed that the manufacturers of the oven and incinerator will design the system based on a maximum organic loading which would occur at the maximum line speed, with use of the highest percent solvent content coating, and the lowest molecular weight solvent (which are typically the most difficult to combust). The designer would also assume 100 percent capture (i.e., no fugitive losses). Although the actual testing time using Reference Method 25 is only a minimum of 1 1/2 hours, the total time required for one complete performance test is estimated at 8 hours, with an estimated overall cost of $4,000.

D.3 MONITORING SYSTEMS AND DEVICES

The purpose of monitoring is to ensure that the emission control system is being properly operated and maintained after the performance test. One can either directly monitor the regulated pollutant, or instead, monitor an operational parameter of the emission control system. The aim is to select a relatively inexpensive and simple method which will indicate that the facility is in continual compliance with the standard.

For carbon adsorption systems, the recommended monitoring test is identical to the performance test. A solvent inventory record is maintained, and the control efficiency is calculated every month. Excluding reporting costs, this monitoring procedure should not incur any additional costs for the affected facility, because these process data are normally recorded anyway, and the liquid volume meters were already installed for the earlier performance test.

For incinerators, two monitoring approaches were considered: (1) directly monitoring the VOC content of the inlet, outlet, and fugitive vents so that the monitoring test would be similar to the performance tests; and (2) monitoring the operating temperature of the incinerator as an indicator of compliance. The first alternative would require at least two continuous hydrocarbon monitors with recorders, (about $4,000 each), and frequent calibration and maintenance. Instead, it is recommended that a record be kept of the incinerator temperature. The temperature level for indication of compliance should be related to the average temperature measured during the performance test. The averaging time for the temperature for monitoring purposes should be related to the time period for the performance test, in this case 1 1/2 hours. Since a temperature monitor is usually included as a standard feature for incinerators, it is expected that this monitoring requirement will not incur additional costs for the plant. The cost of purchasing and installing an accurate temperature measurement device and recorder is estimated at $1,000.

D.3 REFERENCES

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